SAI-79-605-HU

Space Industrialization

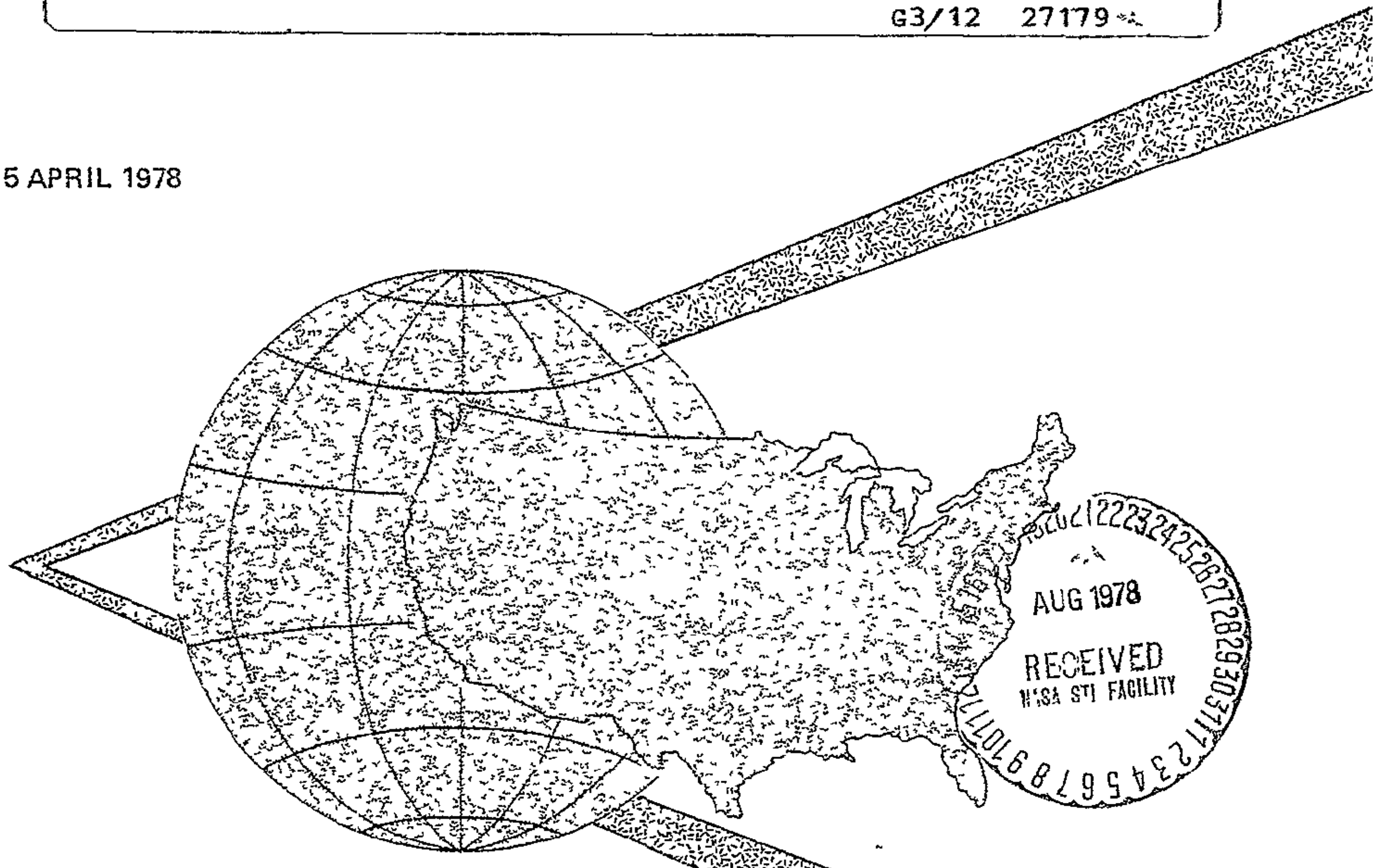
Appendices

(NASA-CR-150755) SPACE INDUSTRIALIZATION. VOLUME 4: APPENDICES Final Report (Science Applications, Inc., Huntsville, Ala.) 461 p HC A20/MF A01 CSCL 22A

N78-28139

Unclas G3/12 27179

15 APRIL 1978



FINAL REPORT

VOLUME 4

SCIENCE APPLICATIONS, INC.

FOREWORD

This $198,962.00 Space Industrialization Study was performed under NASA Contract NAS8-32197 for Marshall Space Flight Center from September 1976 through April 1978. The study was in two parts: Part 1 identified the future opportunities for space industrialization, quantified the potential benefits and developed and analyzed evolutionary program options required to take advantage of these opportunities, Part 2 defined the framework of international governmental, industrial, legal and economic constraints within which space industrialization (SI) must evolve. Step-by-step guidelines to implementation of programs to capitalize on the SI opportunities were formulated using information from Part 1 and Part 2. The study results are documented in four volumes.

1. SPACE INDUSTRIALIZATION - AN OVERVIEW
2. SPACE INDUSTRIALIZATION - OPPORTUNITIES, MARKETS AND PROGRAMS
3. SPACE INDUSTRIALIZATION - WORLD AND DOMESTIC IMPLICATIONS
4. APPENDICES

Part 1 of the study was managed by Dr. Ralph Sklarew and Part 2 by Mr Gerald W. Driggers. Other key SAI participants were Mr. E. Battison, Mr. D. Davis, Mr. Sam Gibson, Mr Mark Klan and Mr. Gordon Collyer. A large portion of the work reported here was accomplished by consultants who occupied roles as principal investigators. The key consultants were:

- Mr. Robert Salkeld - System Planning and Programmatics
- Mr G. Harry Stine - Industrial Planning and Marketing
- Mr. Paul Siegler - Market Assessment and Economic Analysis
- Dr. J. Peter Vajk - World Dynamics and Futures Assessment

A subcontract to Southern Research Institute (SoRI) in Birmingham, Alabama, was managed by Mr. Driggers during Part 1 of the study, prior to his joining SAI Key participants at SoRI were Mr. S J. Causey and Mr. R. Monroe.

Certain individuals within, and with no affiliation to SAI, provided valuable informal data, comments and guidance during the study. The following are recognized for their special contributions.

- W. E Zisch
- G. Hergert
- Coultas Pears
- F. C. Durant III
- Dr. Jerry Grey
- Dr. G. A. Hazelrigg
- B. A. Schriever
- T. F. Walkowicz
- Dr. Klaus Heiss
- Ivan Bekey
- Dr. T. S. Cheston
- Dr. Alan W. Burg
- David Cummings
- Vernon D. Estes
- Dr. Jay T. Shurley
- William Simmons
- J. W. Moyer
- S. R. Hart, Jr.
- A. W. Guill
- Dr. Carleton S. Coon
- Barbara Marx Hubbard
- Donald Waltz
- John Newbauer
- Walter Morgan
- Dr. Gerard O'Neill
- Dr. David Criswell
- James Harford
- William E. Bittle
- J. Frank Coneybear
- Bruce W. Dunbar
- R. G. Woodbridge, III
- Ralph A Rockow
- Dr. Brian O'Leary
- Paul S. Hans
- Dr. Sven W Englund
- Arthur Dula
- Darryl Branscome
- Rashmi Mayur
- Jim Wilson
- R. Prehoda
- Hon Edward Finch
- Chris Basler
- Frederick Ferber
- Mark Frazier
- Katherine D. Hallgarten
- George Koopman
- Hans Wuenscher
- Daniel Cassedy
- Theodore Taylor
- Donna Klan
- Dr. Marta Cehelsky
- Dr. Peter Glaser

The interchange of ideas and concepts provided by technical and informal meetings with Mr. C. L. Gould and Mr. A. D. Kazanowski of Rockwell International during Part 2 of the study is also gratefully acknowledged.

The study was performed under the technical direction of Mr. Rodney Bradford (Part 1) and Mr. Georg von Tiesenhausen (Part 2), Marshall Space Flight Center. Mr. J. von Puttkamer was the program manager for NASA Headquarters, Office of Space Transportation Systems.

Inquiries regarding the study should be addressed to the following:

- Georg von Tiesenhausen
  NASA Marshall Space Flight Center
  Attention: PS01
  Huntsville, AL 35812
  Telephone: (205) 453-2789

- Gerald W. Driggers
  Science Applications, Inc.
  Suite 800
  2109 West Clinton, Avenue
  Huntsville, AL 35805
  Telephone: (205) 533-5900

APPENDIX A

PART ONE FINAL BRIEFING

SPACE INDUSTRIALIZATION STUDY

PART 1 – FINAL BRIEFING

NASA HEADQUARTERS

November 9, 1977

CONTRACT NAS8–32197

AGENDA

INTRODUCTION

- OBJECTIVES
- APPROACH
- TEAM

STUDY OVERVIEW

- FUTURE SCENARIOS
- COMPILING CANDIDATES
- TERRESTRIAL ALTERNATIVES
- MARKET SURVEYS
- PROGRAM DEVELOPMENT/ ANALYSIS

CONCLUSIONS

- WHAT SHOULD NASA DO?
- WHY HURRY?
- WHAT NEXT?

PART 1 STUDY OBJECTIVES

Part 1 of the Space Industrialization Study at Science Applications, Inc., is structured around answering the "What", "Why" and "How" of space industrialization with a $100K, 1-1/2 person-year level of effort, 10 month study.

The answers for the time period 1980 through 2010 are developed against a background of alternate possible futures in terms of candidate opportunities for space industries, potential markets for space products or services, assessment of space production versus terrestrial alternatives, required major systems, and possible programs and programmatics. Activities specifically of a scientific or military nature are not considered.

The methods used to develop these answers stress

- Conceptualization to scope possible answers and to develop new ideas
- Compilation of previous works and data
- Categorization to structure the findings and to illuminate further data requirements
- Evaluation to extract the implications of study results.

The major contributions of this study are in the structuring and logic imparted to the numerous concepts presently being discussed.

PART 1 – STUDY OBJECTIVES

- WHAT IS SPACE INDUSTRIALIZATION?
  - √ CANDIDATE OPPORTUNITIES
- WHY INDUSTRIALIZE SPACE?
  - √ THE POTENTIAL MARKETS
  - √ COMPARISON TO TERRESTRIAL ALTERNATIVES
  - √ IMPLICATIONS OF ALTERNATIVE FUTURES
- HOW COULD SPACE BE INDUSTRIALIZED?
  - √ THE MAJOR SYSTEMS
  - √ THE STEPWISE PROGRAMS
  - √ INVESTMENTS AND REVENUES
  - √ INITIATIVES

WHAT IS SPACE INDUSTRIALIZATION?

Semantics, popular literature, the NASA Five Year Plan, technical meetings and assorted initiatives by divers groups has led to substantial confusion concerning space industrialization. SI is most importantly not a "program"; it cannot be planned, orchestrated or directed. The definition shown here is based on our observations of what currently is and what will evolve.

A point of the greatest significance. The level of activity and rate of growth of SI can be most directly stimulated by government action and investment in concert with industry.

WHAT IS SI?

SPACE INDUSTRIALIZATION IS NOT . . .

SPACE INDUSTRIALIZATION IS NOT . . .

- A "PROGRAM".
- A SPACE STATION.
- SPACE COLONIZATION.
- LARGE SPACE STRUCTURES.
- NEW OR 15 YEARS AWAY.
- A SPECIFIC ACTIVITY.

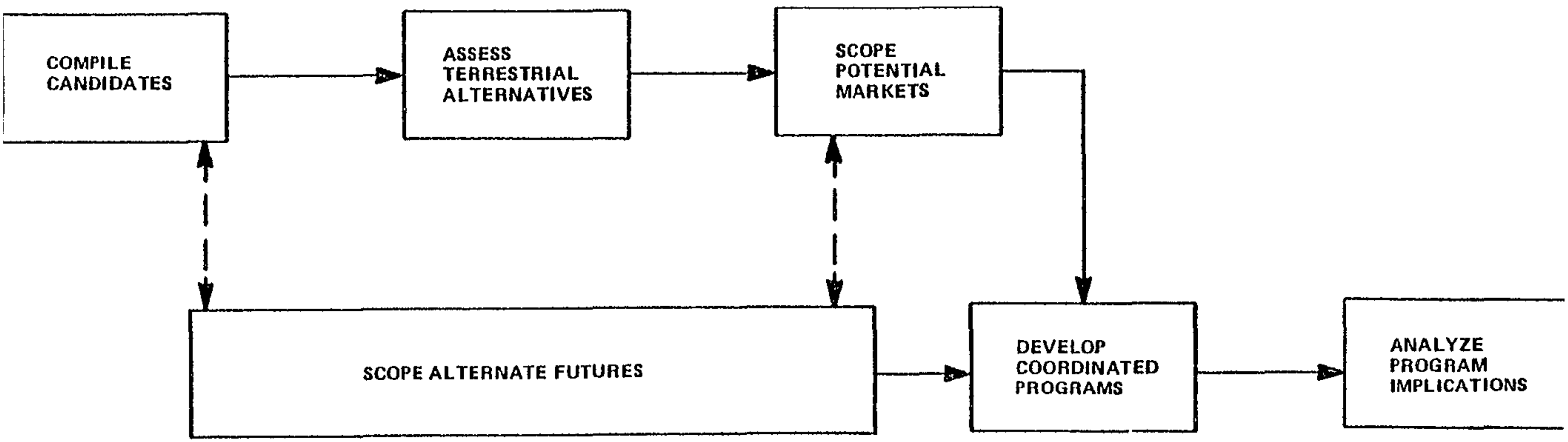
SPACE INDUSTRIALIZATION IS. . .

- INDUSTRY AND GOVERNMENT WORKING TOGETHER FOR PROFIT AND PRAGMATIC BENEFIT UTILIZING SPACE

PART 1 STUDY APPROACH

To answer "What", the study began with compiling and categorizing candidate space industrial opportunities. To answer "Why", markets, future needs and alternatives were investigated. Potential markets were scoped for the major candidates. These tasks were conducted interactively with efforts to scope alternate possible futures and determine future needs A spectrum of candidates for space utilization were assessed versus their terrestrial alternatives. "How" was answered in terms of programs and their implications Programs were developed around placing the space activities corresponding to the most promising candidates in a logical time sequence for each alternate future. The programs were analyzed for major system requirements and timing as well as investments and benefits.

PART 1 – STUDY APPROACH



PART 1 STUDY TEAM ORGANIZATION

The study team features a heavy emphasis on expert consultants, top level corporate involvement, a blend of youth and experience in a new group without inherent aerospace bias, and a large and growing list of highly visible individuals with diverse backgrounds who have volunteered to review and comment on study directions and findings These individuals serve the multiple functions of peer review, wide dissemination of the study results and stimulation of interest in space industrialization. The consultants are integrated into the study as team members and represent almost half of the study efforts.

PART 1 – STUDY TEAM ORGANIZATION

INDIVIDUALS SOLICITED TO:

- BROADEN INTEREST IN SI/SAI PROGRESS
- PROVIDE INFORMAL COMMENTS
- NO COMMITMENT OR ENDORSEMENT IMPLIED

ISAAC ASIMOV	IVAN BEKEY
JOHAN BJORKSTEN	BEN BOVA
STEWARD BRAND	HARRISON BROWN
WILLIAM BROWN	CARLETON COON
EDWARD CORNISH	HUGH DOWNS
FREDERICK DURANT III	SVEN ENGLUND
WILLIAM ESCHER	EDWARD FINCH
PETER GLASER	THEODORE GORDON
JERRY GREY	A. W GUILL
G A HAZELRIGG	BARBARA MARX HUBBARD
KERRY JOELS	ARTHUR KANTROWITZ
JOHN PLATT	WILLIAM PICKERING
GENE RODDENBERRY	NEIL RUZIC
B A SCHRIEVER	W H. SIGFRIED
THEODORE TAYLOR	JOHN TEEM
T F. WALKOWICZ	DONALD WALTZ

SAI CORPORATE REVIEW

J R BEYSTER	W. E ZISCH
SAI PRESIDENT CHAIRMAN OF THE BOARD	SAI VICE-CHAIRMAN OF THE BOARD

R. SKLAREW	G DRIGGERS
SYSTEMS PLANNING ENVIRONMENTAL ASSESSMENT	AEROSPACE ENGINEERING

S GIBSON	R SALKELD	J. VAJK	P SIEGLER	G STINE
ECONOMIC & SYSTEMS ANALYSIS	SYSTEMS PLANNING & ANALYSIS	WORLD DYNAMICS	BUSINESS ECONOMICS	INDUSTRIAL ENGINEERING MARKETING

D CRISWELL	S KORNISH	R PREHODA	C BATES	S CAUSEY	D DAVIS	E BATTISON
LUNAR RESOURCES	PROGRAM COSTING	TECHNOLOGY FORECASTING	MATERIALS ENGINEERING	MECHANICAL ENGINEERING	SPACE ENVIRONMENT	RESOURCE ECONOMICS

R. STERNBACH
TECHNICAL ARTWORK

AGENDA

INTRODUCTION

- OBJECTIVES
- APPROACH
- TEAM

STUDY OVERVIEW

- FUTURE SCENARIOS
- COMPILING CANDIDATES
- TERRESTRIAL ALTERNATIVES
- MARKET SURVEYS
- PROGRAM DEVELOPMENT/ ANALYSIS

CONCLUSIONS

- WHAT SHOULD NASA DO?
- WHY HURRY?
- WHAT NEXT?

PRECEDING PAGE BLANK NOT FILMED

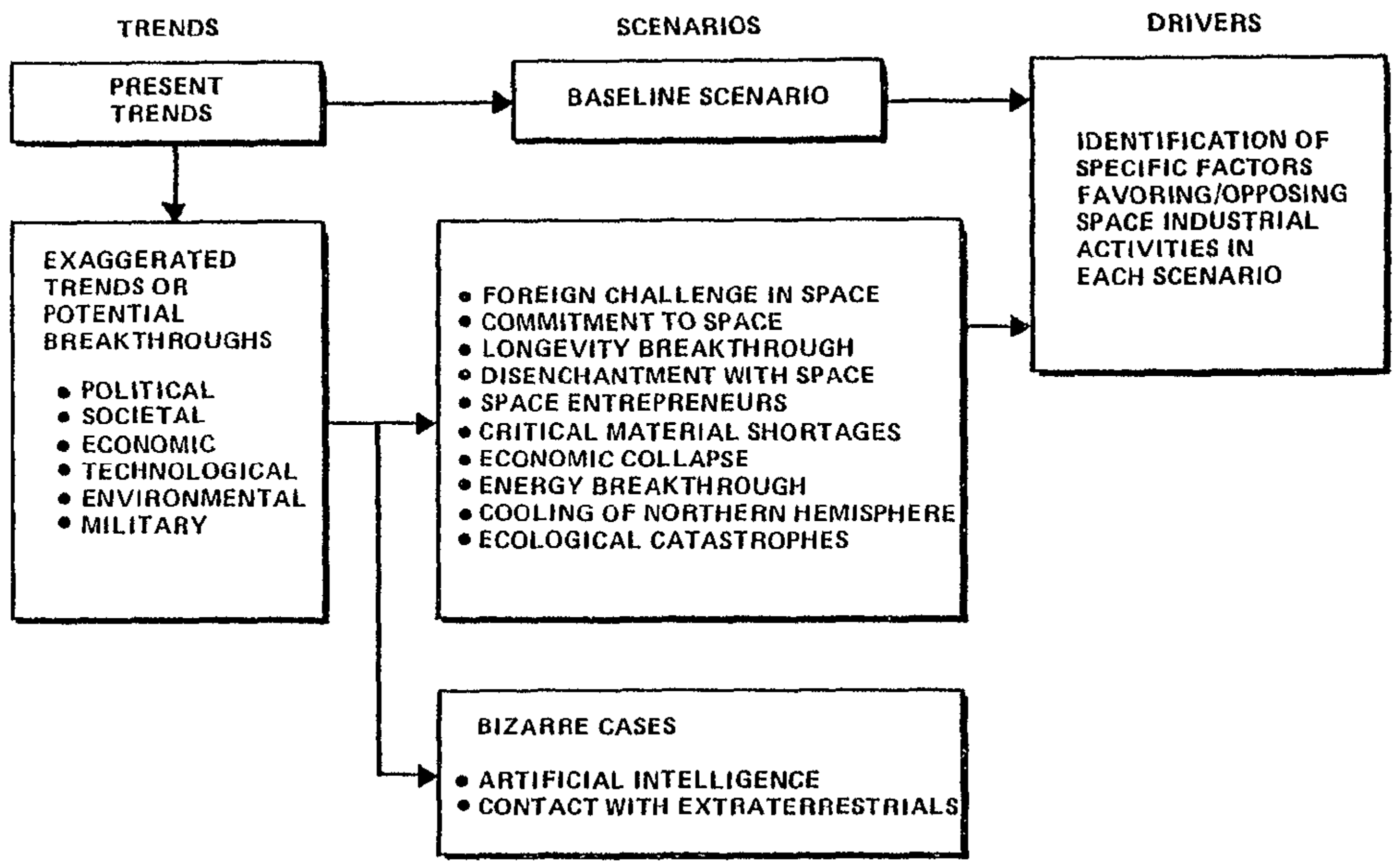
FUTURE SCENARIOS - METHODOLOGY

Since the future cannot be predicted with any confidence or certainty, we have generated a series of scenarios for the future of the United States and the world as a whole over the next three decades to bracket what the future might actually be. In this sense, our scenarios do not attempt to predict the future but only to describe what might be considered plausible courses of events which could develop from the present state of national and world affairs. Each scenario is described in terms of the political, societal, economic, technological, environmental, and military aspects of the human system.

Based on simple extrapolations of present conditions and trends, a baseline scenario was first developed which includes no "surprises" Major developments which could occur during the next decades in each of the principal aspects of the human system were then selected as triggers for alternate scenarios. (Military developments have explicitly been excluded from consideration.) Each of the alternate scenarios includes most of the features of the baseline scenario as well, unless specific factors in the alternate scenario would vitiate particular features of the baseline Two possible developments in the next few decades were considered briefly but proved to be too "bizarre", in that scenario development would depend too strongly on details of these developments which are presently unknown or unknowable. These developments are artifical intelligence and contact with extraterrestrial intelligence. Both of these could have profound impacts on future space programs and should be monitored in future NASA planning.

As the scenarios were developed, it was possible to identify specific factors or drivers in each scenario which would make specific space industries more attractive or less attractive from political, economic, societal, environmental, or technological considerations. (Military considerations, again, were deliberately omitted.) Thus it is possible to identify opportunities for space enthusiasts to advocate specific space activities, these vary significantly among various scenarios, but it appears that virtually any probable future contains substantive space industrialization goals

FUTURE SCENARIOS – METHODOLOGY



SCENARIO CONTENT

As explained on the previous chart extrapolation of trends form the basis for the so-called "Baseline" scenario. This included predictions of events and attitudes. Other scenarios contained exaggeration or elimination of trends and attempted to couple these with events and attitudes that were not necessarily predictive with a high probability. From the aggregate of events, attitudes and trends came an interpretation of opportunities for exploitation or advocacy involving space industrialization. It was assumed that these opportunities would be capitalized on.

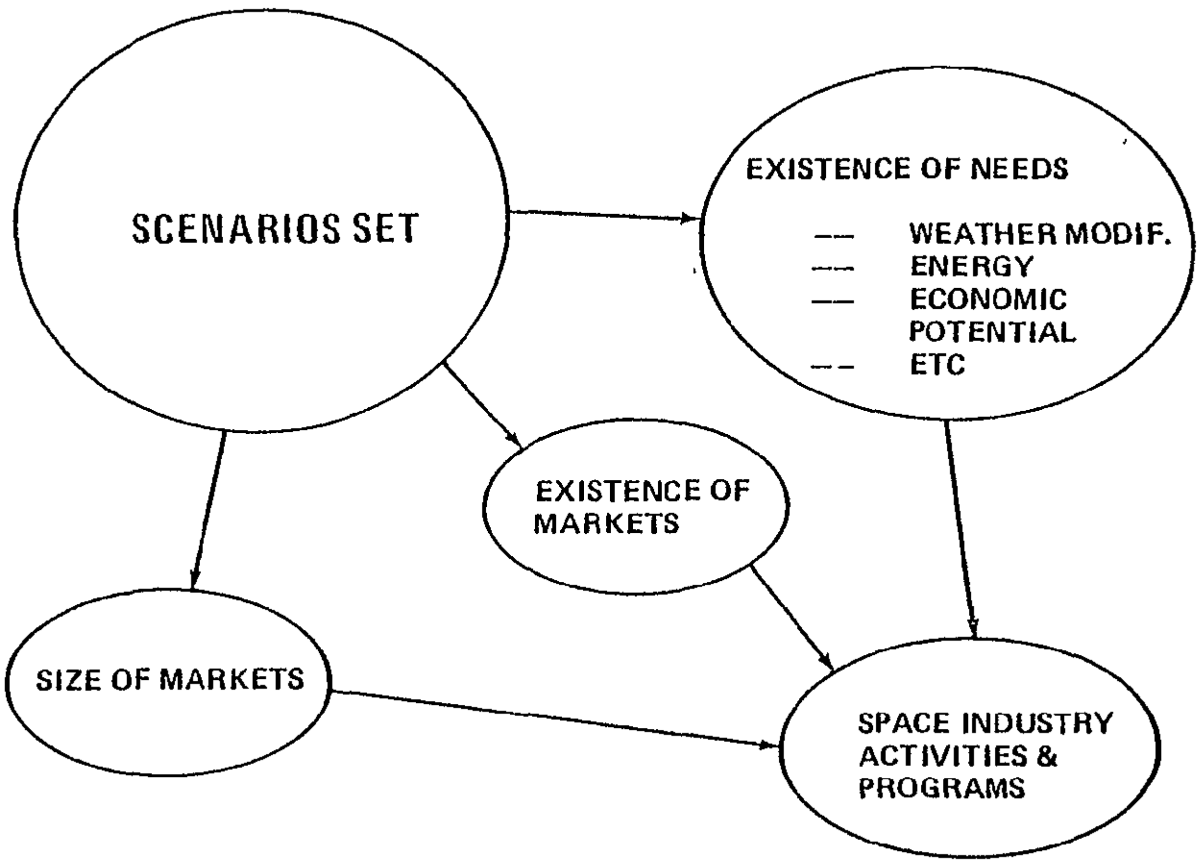
SCENARIO CONTENT

	1980	1985	1990	1995	2000	2005	2010
BASIC TRENDS THROUGHOUT THE PERIOD							
POLITICAL							
SOCIETAL	EVENTS, ATTITUDES, TRENDS WHICH MAY HAVE DIRECT OR OBLIQUE EFFECTS ON THE OPPORTUNITY FOR SPACE INDUSTRY GROWTH AND DEVELOPMENT.						
ECONOMIC							
TECHNOLOGICAL							
ENVIRONMENTAL							
MILITARY							

SCENARIO ROLES

The interpretations discussed with the previous chart set needs and the existence of certain markets. Then a general program can be formulated composed of the appropriate space activities which fulfill the perceived needs and markets at the appropriate time. Another important scenario function was in market sizing since that drove the magnitudes of various systems within the programs and set timing for events such as introduction of new capabilities

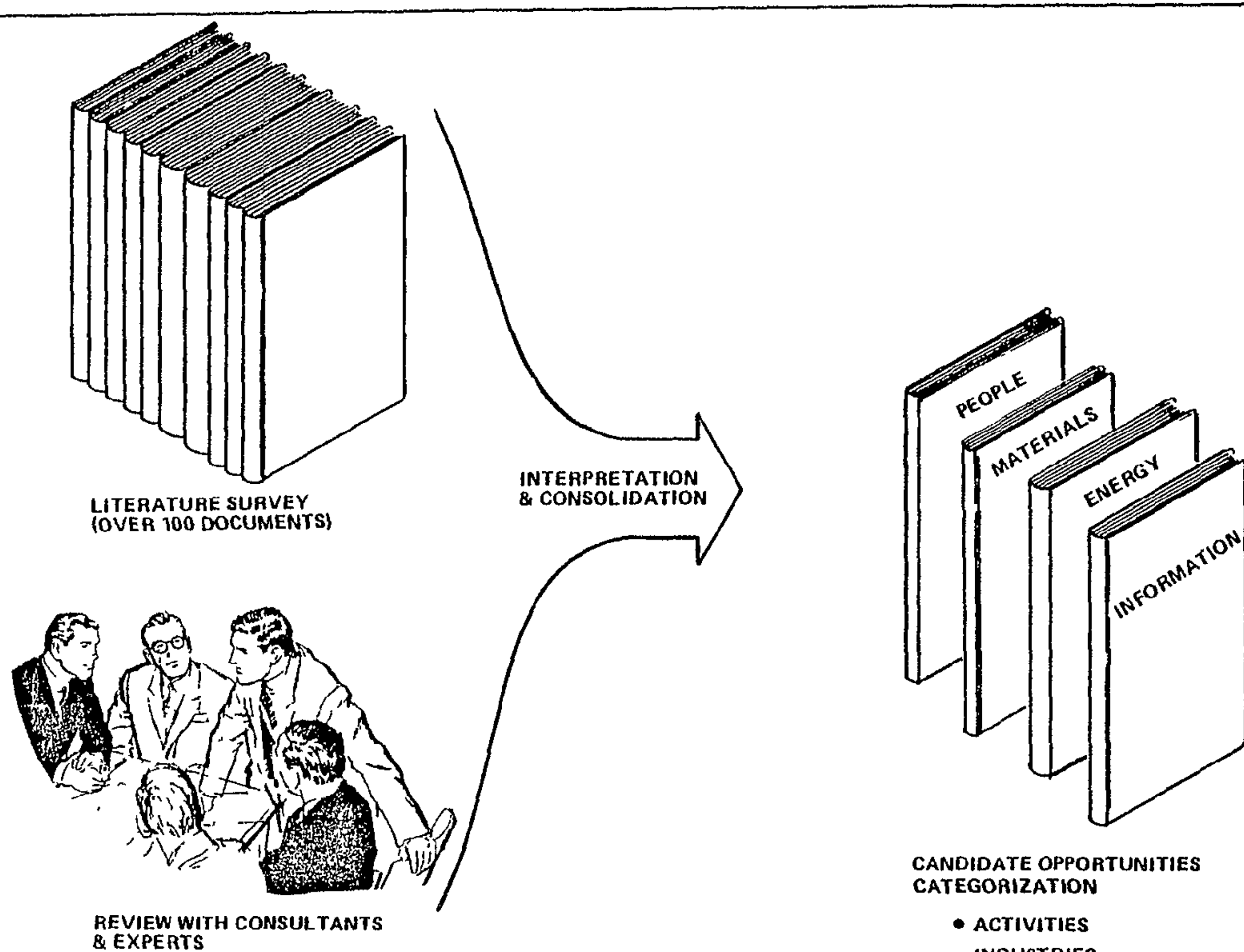
SCENARIO ROLES



COMPILING CANDIDATES - METHODOLOGY

Candidate space industrial opportunities were compiled by surveying the extensive literature on theoretical space advantages, results of space experiments, and projections of possible space products and services as well as by discussions with numerous experts in the fields of space processing, materials science, lunar and asteroidal resources, communications, remote sensing, electric power supply, and transportation. The compiled data was augmented by concepts evolved by the study team and consolidated into four categories, activities in space with information, energy, materials and people Within an activity, each concept was categorized by the level of detail into industries and specific uses for products and services.

COMPILING CANDIDATES – METHODOLOGY



RESULTS OF COMPILATION

The resulting compilation of candidates identifies, characterizes, and categorizes over 250 uses for specific products and services. For example, categorized within information activities is the communications industry which has aggregated services for individual 2-way, group 2-way, up/down link only, and remote control. Twenty-five uses have been identified and described for these services among the sixty-seven specific uses for information activities. An example of a specific use is personal communications using a portable 2-way radio (wrist radio).

This compilation was based on the few data presently available and on theoretical grounds The totals shown are mainly representative of the efforts expended rather than absolute limits As new data becomes available, unforeseen opportu- ities are expected to develop as well as some being shown to be infeasible.

RESULTS OF COMPILATION

- A LARGE LIST OF CANDIDATES AND MANY USES WERE IDENTIFIED, THE LIST IS NOT EXHAUSTIVE

ACTIVITY PEOPLE

USES
5
5
6
3
3
3
6
28

ACTIVITY MATERIALS

USES
8
11
19
62
23
24
147

ACTIVITY ENERGY

USES
4
5
1
3
13

ACTIVITY INFORMATION

INDUSTRIES	USES
COMMUNICATIONS	25
OBSERVATIONS	19
NAVIGATION	3
LOCATION	9
SENSOR POLLING	11
TOTAL	67

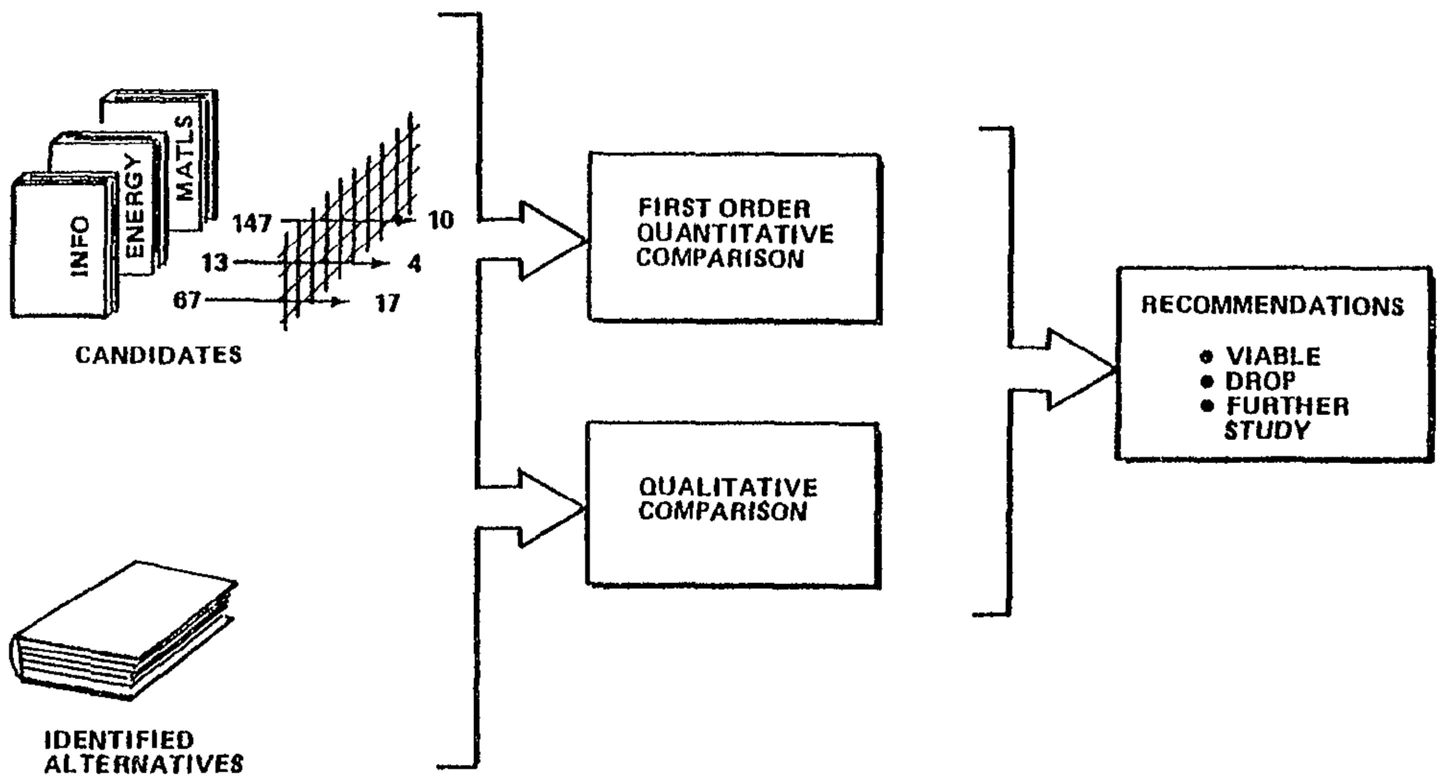
TOTALS REPRESENTATIVE ONLY

TERRESTRIAL ALTERNATIVES - METHODOLOGY

Thirty-one representative uses of space (candidate opportunities) were compared to potential Earth based alternatives Comparisons were based on examining the initial cost of installation on a first order basis and a cursory review of qualitative factors such as ease of use, reliability, technology requirements, etc. If costs and capability obtained appeared comparable between the alternatives, they were retained for further study In certain instances the identified space uses exhibited much lower cost for similar capability or the reverse. These were identified as clearly viable candidates Where cost and/or capability were clearly superior for the Earth alternative, the candidate was dropped from further consideration.

TERRESTRIAL ALTERNATIVES – METHODOLOGY

- CANDIDATES SCREENED TO REDUCE NUMBER BY CONSIDERING:
  - — DATA BASE FOR MARKET ANALYSIS
  - — GENERAL APPEAL.
  - — TEAM JUDGEMENT ON BEST CANDIDATES.



TERRESTRIAL ALTERNATIVES - QUALITATIVE COMPARISON EXAMPLE

Four candidates are shown with examples of the types of qualitative comparisons made between space and Earth based alternatives. From the integral of qualitative factors, judgments were made on the probable viability of each candidate.

In the personal communications concept the service offered by a space-based system leads to the conclusion that it is probably viable

The space relay for education does not seem viable when compared to video tape/disc systems for a non-interactive educational system. Fully interactive educational systems were not assessed

TERRESTRIAL ALTERNATIVES

QUALITATIVE COMPARISON EXAMPLE

SPACE INDUSTRIALIZATION CANDIDATE	TERRESTRIAL ALTERNATIVE	ADVANTAGES FOR TERRESTRIAL ALTERNATIVE	DISADVANTAGES FOR TERRESTRIAL ALTERNATIVE	RECOMMENDATIONS
• PERSONAL COMMUNICATIONS (WRIST RADIO)	• HARDLINES–FIBER OPTICS/ GLASS WAVE GUIDES • HARDLINES–COMBINER MICROWAVE–METALLIC CONDUCTORS • RF–CB (HF VHF UHF)	• HIGH DATA RATE, LOW COST RAW MATERIAL UNLIMITED • IN PLACE SYSTEM, LOW TECHNICAL RISK • EXISTING SYSTEM, LOW COST FLEXIBLE TO UPDATES	• PRODUCTION AND OPERATION UNPROVEN • HIGH INSTALLATION COST HIGH MAINTENANCE • LIMITED CAPABILITIES, CHANNELS AND RANGE	• CONTINUE TO ANALYZE SPACE OPPORTUNITIES, PROBABLY VIABLE
• EDUCATION (SPACE RELAY)	• VIDEO TAPE/DISC (PROGRAMMED INSTRUCTIONS) • GROUND BASED T V	• EXISTING SYSTEM & TECH NOLOGY, LOW COST, FLEXIBLE • EXISTING SYSTEM & TECH NOLOGY, LOW COST RECEIVER INSTALLATION & OPERATION	• UPDATING IS EXPENSIVE • TRANSMITTER SITES EXPENSIVE	• DOES NOT APPEAR TO BE A VIABLE SPACE OPPORTUNITY
• NIGHT LIGHT	• TERRESTRIAL LIGHTING	• EXISTING SYSTEM FLEXIBLE TO SCHEDULE	• HIGH ENERGY CONSUMPTION NOT FLEXIBLE TO GEOGRAPHIC LOCATION	• CONTINUE TO ANALYZE SPACE OPPORTUNITIES
• SUPER CONDUCTORS	• TERRESTRIAL PROCESSING & FABRICATION	• EMERGING TECHNOLOGY – LAMINATED RIBBON • NEEDED FOR CONSERVATION • NEEDED FOR GENERATION	• CURRENT PRODUCTION LIMITED TO LABORATORY QUANTITIES	• CONTINUE TO ANALYZE SPACE OPPORTUNITIES

SAI 2808

RESULTS OF ALTERNATIVES COMPARISON

INFORMATION

Most services need further assessment based on additional data before a clear choice is possible A few within the information activity are unique or almost so due to the view presented from space.

RESULTS OF ALTERNATIVES COMPARISON

	PREFERRED APPROACH		
	SPACE	?	EARTH
INFORMATION			
Wrist Radio (General Use)		√	
Urban/Police Wrist Radio			√
3-D Holographic Teleconferencing		√	
National Information Services		√	
Electronic Mail		√	
Disaster Communications Set	√		
Advanced TV Broadcast		√	
Vehicle Inspection		*	
Global Search & Rescue	√		
Nuclear Fuel Locators	√		
Ocean Resources	√		
Transportation Services (Equipment Sales)		*	
Coastal Anti-Collision Radar (Equipment Sales)			√
Rail Anti-Collision System		*	
Personal Navigation Sets (Equipment Sales)	√		
Vehicle/Package Locator	√		
Voting/Polling Wrist Set		√	

*Data not readily available on alternatives.

RESULTS OF ALTERNATIVES COMPARISON

ENERGY

If SPS results in low cost power, it may be the preferred approach. However, environmental, health, legal and technical considerations require more data before any preference can be determined

SPACE INDUSTRIALIZATION
SCIENCE APPLICATIONS INC

RESULTS OF ALTERNATIVES COMPARISON

	PREFERRED APPROACH		
	SPACE	?	EARTH
ENERGY			
Solar Power Satellite (First SAT in 1996)			
49 5GW at 27 MILS/KWH		√	
60 10GW at 11 5 MILS/KWH → 7 1 MILS/KWH	√		
60 10GW at 27 MILS/KWH		√	
Urban Night Illuminator		*	
Energy Monitor			√
Nuclear Waste Disposal		*	

*Data Not Readily Available on Alternatives.

RESULTS OF ALTERNATIVES COMPARISON

MATERIALS

Only one materials industry is really unique---making jewelry from immiscible precious metals Most materials activity products could have terrestrial alternatives in terms of alternate means of manufacture, substitute materials or replacement of need

RESULTS OF ALTERNATIVES COMPARISON

	PREFERRED APPROACH		
	SPACE	?	EARTH
MATERIALS			
Drugs and Pharmaceuticals		√	
Electronics			
Semiconductors		√	
Electrical			
Magnets		√	
Superconductor (Generating Only)		√	
Electron Tubes			√
Optical			
Fiber Optics		√	
Special Metals			
Perishable Cutting Tools		√	
Bearings and Bushings		√	
Jewelry	√		
Wire (High Strength, Low Resistance, etc)			√

TERRESTRIAL ALTERNATIVES - RESULTS

The results of the alternatives comparison are summarized under three of the four activities identified. The People activities previously examined for market potential are dependent on the uniqueness of space and thus have no Earth alternative.

TERRESTRIAL ALTERNATIVES – COMPARISON RESULT

	INFO	ENERGY	MATERIALS
• VIABLE (CLEAR WINNER)	6	0	1
• DROP (CLEAR LOSER)	2	1	2
• FURTHER STUDY (INDETERMINANT)	9	3	7

RECOMMENDATION

CONTINUE STUDY OF: 15 INFO CANDIDATES
3 ENERGY CANDIDATES
8 MATERIALS CANDIDATES

MARKET SURVEYS - METHODOLOGY

The methodology for scoping potential markets was developed to provide broad banded order of magnitude revenue projections The methodology is based on historical performance of analogous products or services on forecasts of markets and on expert opinion to assess the universe of potential users (as a function of cost), penetration delays and saturation time for services, sales and replacements, as appropriate. Best and worst case banding was used. The revenues developed were then based on projected costs usage and the banded number of users.

In Part 1 of the study the markets surveyed are divided as

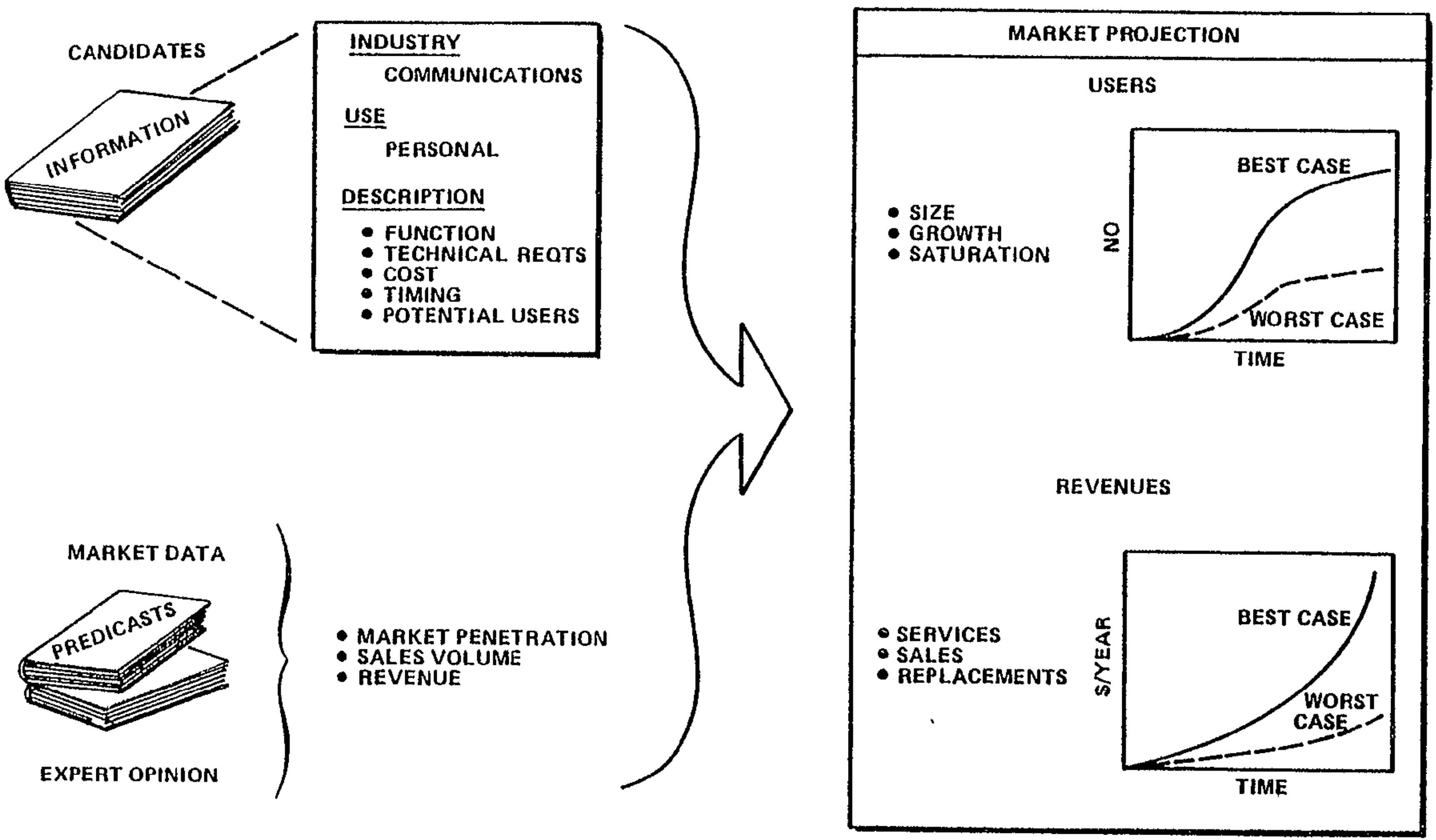
<u>U S.</u>

Information.	15	Energy	3
Materials	8	People	4

<u>International</u>

4

MARKET SURVEYS – METHODOLOGY



PERSONAL COMM MARKET SURVEY EXAMPLE

FUNCTION -- Provide private personal communications between any two individuals having the device. It is implied that persons will have the device only if they spend a large part of their time in a beam area. After national expansion this will be, for all practical purposes, anywhere in the US.

TECHNICAL REQUIREMENTS -- Small low power pocket or wrist device interfacing with a large space borne antenna with appropriate power and switching capability Allocation of sufficient frequencies (old or new) to handle the projected growth is assumed.

COST -- Analogous product costs for small hand held electronic devices were examined. This included calculators, digital watches and portable CB systems. Resulting average price spread selected was $300 (at entry) down to $30 (near saturation). Market size and cost per call were traded in a fashion to assure revenues greater than the initial investment by year five, thus assuring an early ROI. The result was a cost/call range of $3 00 to $1.31 in the first five years with a steady decrease to $0 30/call at 15 years.

MARKET SURVEYS – EXAMPLE

SPECIFIC ASSUMPTIONS

INDUSTRY – COMMUNICATIONS   USE – PERSONAL

DESCRIPTION

- FUNCTION – INDIVIDUAL PRIVATE COMMUNICATIONS OVER LONG DISTANCE UNCONSTRAINED BY CONNECTION
- TECHNICAL REQUIREMENTS –

  SMALL PORTABLE DEVICE

  LARGE SPACE BORNE SYSTEM

  PROPER AND SUFFICIENT FREQUENCY ALLOCATION
- COST – DEVICE IS \$300 AT ENTRY, DECREASING TO \$30 AT SATURATION

  COST/CALL DECREASES \$3 00 → \$1 31 IN FIRST 5 YEARS

  COST/CALL IS \$0 30 AT 15 YEARS

TIMING -- Scenario guidelines set technology availability from 1984 to 1990. Analogous history in domestic communications satellites show a delay of 8 years in obtaining a license. Delay attempts by such companies as AT&T are to be expected. A relatively large investment (about $500M to $1,000M) is anticipated implying some delay in itself. Even under the best of circumstances it is difficult to imagine less than six years from technology demonstration to system implementation. Maximum period used was twelve years. Conceived competing product resistance lead to a medium stretchout before growth of 5 years. Analogies to color television saturation rates were used to imply a moderate track (20 years) to ultimate saturation.

POTENTIAL USERS -- As with calculators and pagers, the initial market (2 to 5 years) is anticipated to be the professional and businessman. With increased capacity, higher order market saturation and declining cost the universe of users should become the entire population above some age. A cutoff age of 16 was arbitrarily selected. There is now over 1 telephone for every 2 people in the US. An ultimate saturation of 1 for 4 was assumed at 20 years.

MARKET SURVEYS – EXAMPLE (CONTINUED)

SPECIFIC ASSUMPTIONS

- TIMING - SPECIFICS ARE SCENARIO/PROGRAM DEPENDENT
  - TECHNOLOGY AVAILABLE ABOUT 1984 TO 1990
  - TECHNOLOGY DEMONSTRATION TO SYSTEM IMPLEMENTATION PERIOD OF 6 TO 12 YEARS
  - MEDIUM STRETCHOUT BEFORE GROWTH ABOUT 5 YEARS
  - TRACK TO ULTIMATE SATURATION ABOUT 20 YEARS
- POTENTIAL USERS –
  - INITIAL 2 TO 5 YEARS PROFESSIONAL AND BUSINESSMAN
  - 1 UNIT PER 4 PEOPLE ASSUMED AT 20 YEARS

MARKET POTENTIAL - WRIST RADIO

The market potential for wrist radio depends greatly upon fees from user calls. More revenues are generated with lower fees due to the greater usage. Telephones and CB's were used as analogous products to determine market penetration, delays, etc. A decrease from an initial $3 per call to 30¢ per call was assumed, accompanied by a corresponding drop in transceiver cost in year 10 Even the best case is conservative, assuming only 1/4 of the population as users. The worst case includes delays in cost reduction and reduction of users to those having multiple phones. Anticipated legal/political resistance can delay entry 3 to 10 years.

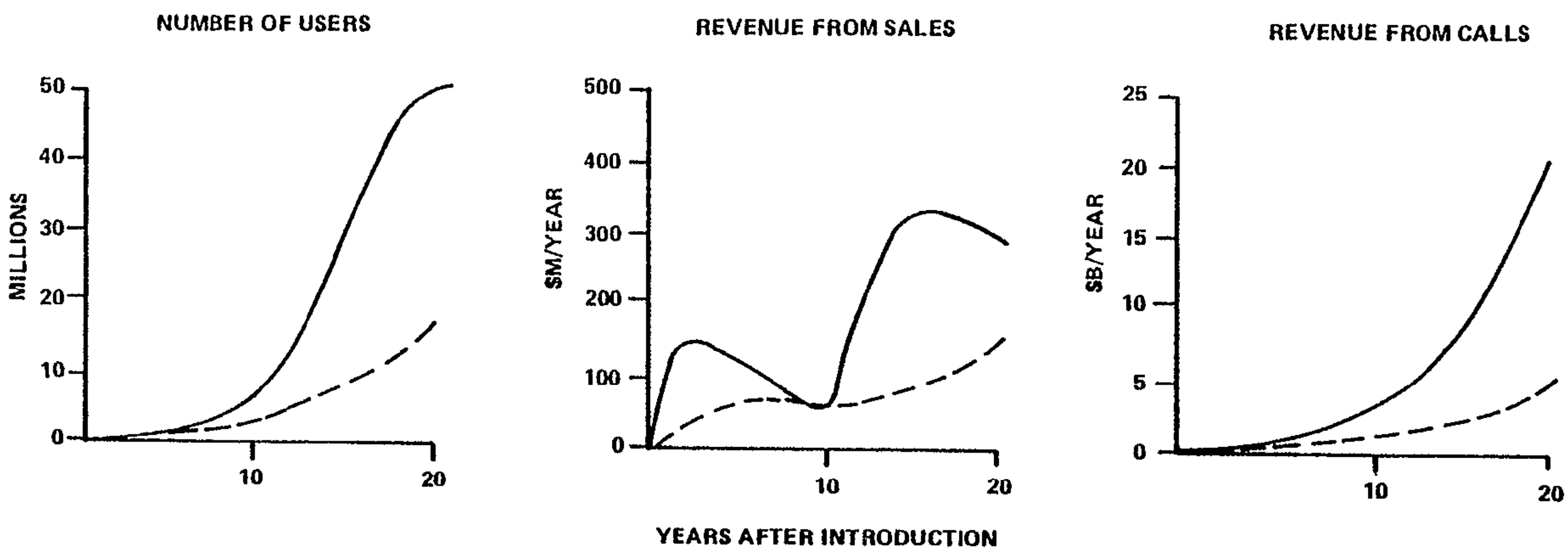
MARKET SURVEY – WRIST RADIO

ACTIVITY: INFORMATION

INDUSTRY. COMMUNICATIONS

USE: PERSONAL

- BY EMPLOYING LARGE ORBITAL ANTENNAS, THE GROUND ANTENNA SIZE CAN BE REDUCED, PERMITTING GENERAL USE MOBILE COMMUNICATIONS.



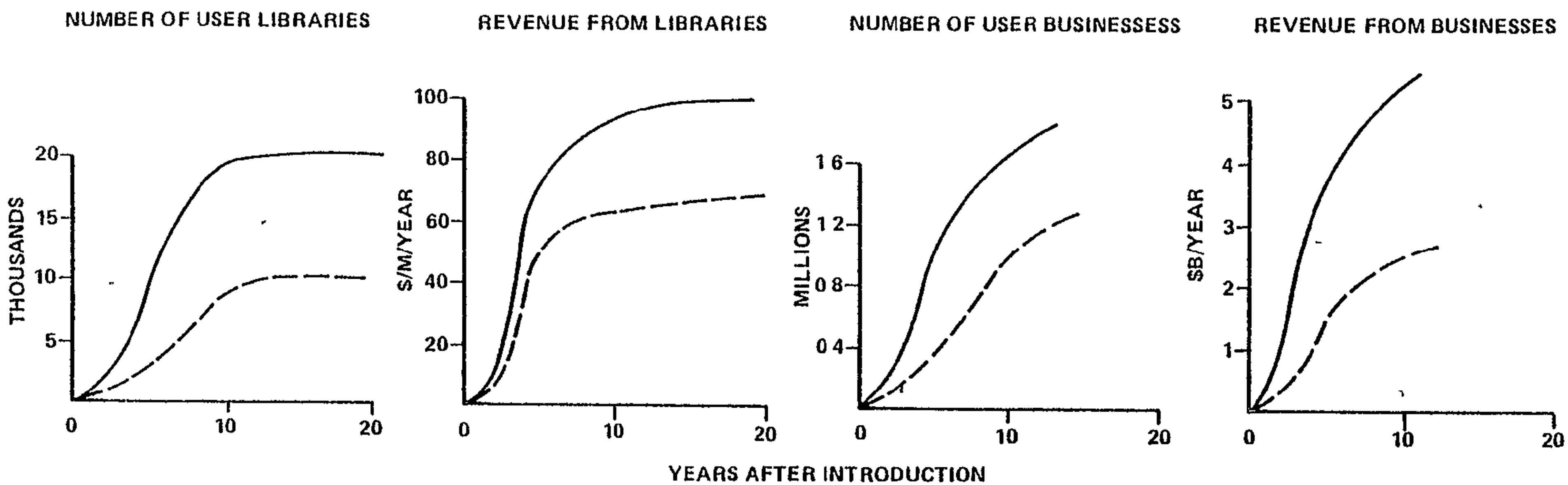
MARKET SURVEY - INFORMATION SERVICES

Information services are envisioned to provide ready access to the largest libraries and data bases Initially the service may be for library to library exchange to reduce the costs of small libraries while expanding their services A few tens of thousands of libraries may use the service However, as the service expands into the business market, there are millions of projected users A final phase, individual home usage, was not projected but could be expected to be even larger.

MARKET SURVEY – INFORMATION SERVICES

ACTIVITY.	INFORMATION
INDUSTRY.	COMMUNICATIONS
USE.	LARGE SCALE DATA TRANSFER

- BY EMPLOYING MULTI-BEAM ANTENNAS, PROVIDE ACCESS TO LARGE LIBRARIES FOR SMALLER LIBRARIES AND BUSINESSES.



MARKET SURVEY - SOLAR POWER SATELLITE

Solar power satellites could begin to provide significant power by 2010. Initial satellites will be made of terrestrial materials but thereafter non-terrestrial material from lunar or asteroidal sources appear promising. The installed power is more a function of technical production times than market size, saturation of the market is not envisioned by 2010. The revenues generated depend upon the charges for power for which projections range from 7 to 27 mils/Kw-hr. These projections span the spectrum from Glaser to O'Neill

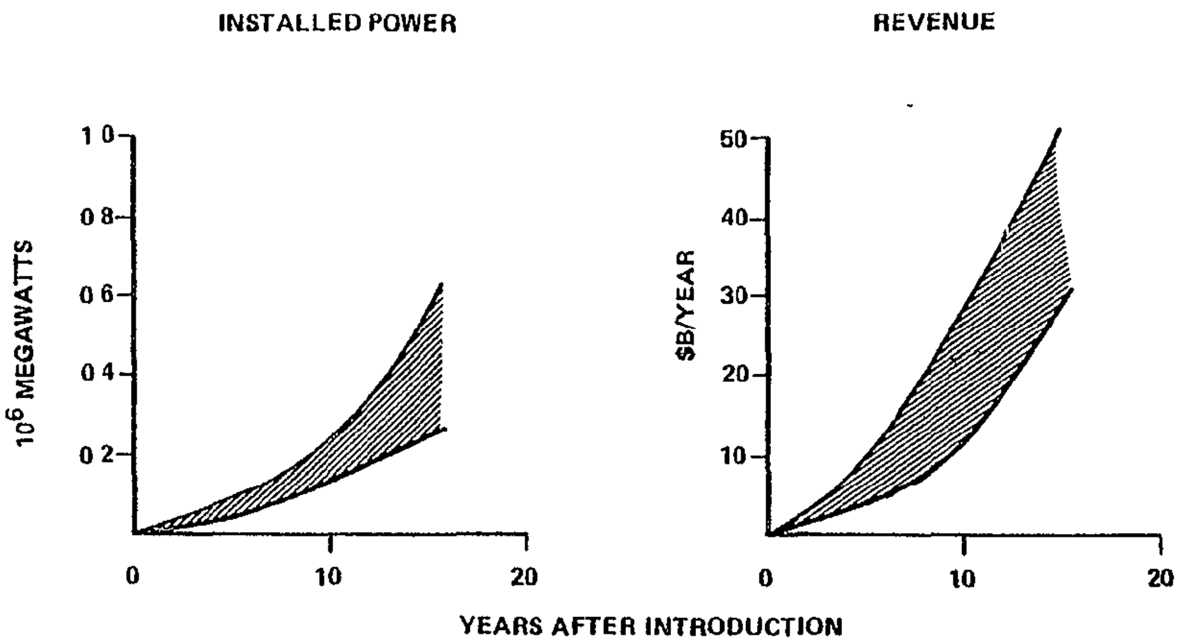
MARKET SURVEY – SOLAR POWER SATELLITE

ACTIVITY. ENERGY

INDUSTRY. SATELLITE POWER SYSTEM

USE: SOLAR POWER SATELLITE FOR ELECTRICAL PRODUCTION

- UTILIZE FULL SOLAR FLUX TO GENERATE ELECTRICITY IN ORBIT AND BEAM IT BY MICROWAVE FOR USE ON EARTH



MARKET SURVEYS - DRUG PRODUCTS

As an example of the drugs and pharmaceuticals markets, the potential market for isoenzymes was developed. Though total usage continues to expand, reduced transportation costs will reduce costs significantly, perhaps, resulting in reduced revenues.

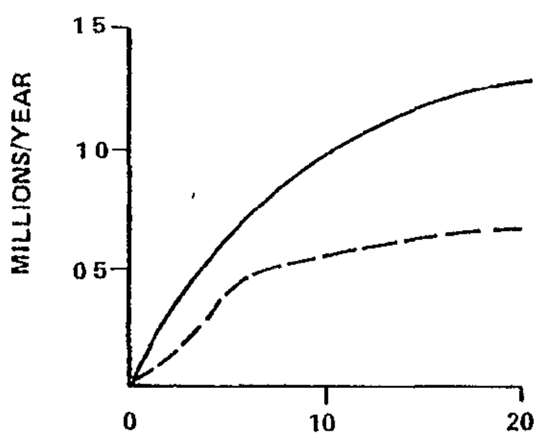
Overall, the potential markets for space produced drugs and pharmaceuticals (based on more precise separation and higher purity due to reduced gravity) could be 25% of the new drug market (after transportation costs have been markedly reduced), approximately $600M/year

MARKET SURVEYS — DRUG PRODUCTS

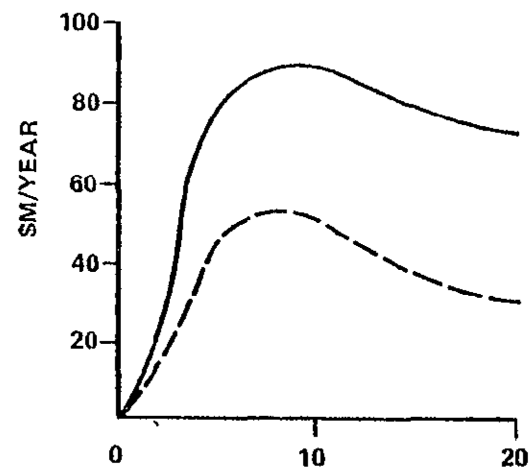
ACTIVITY:	MATERIALS
INDUSTRY	BIOLOGICAL
USE	PRODUCTION OF ISOENZYMES

HIGH PURITY DRUGS CAN BE MADE BY ORBITAL SEPARATION UTILIZING "ZERO" GRAVITY.

DOSES



REVENUE



YEARS AFTER INTRODUCTION

MARKET SURVEY - COMMERCIAL TRAVEL

With a low cost shuttle system, commercial travel into orbit or long distance global travel is possible. Point to point times for global transportation by shuttle would be within two hours The number of passengers is a strong function of the cost (as seen in present long distance travel) - with 10^4 passangers/year projected at $25/lb. - (for revenues of $50M/year), 10^5 passengers/year at $10/lb. (for $100M/year) and 10^6 passengers/year at $5/lb. (for $1B/year).

This market projection assumes a drop from $25/lb. to $10/lb. in year 10

MARKET SURVEY – COMMERCIAL TRAVEL

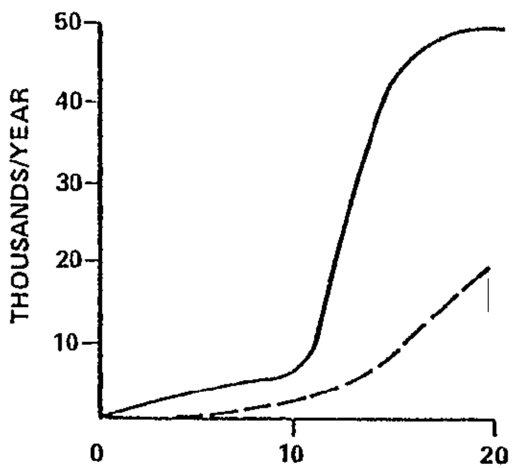
ACTIVITY: PEOPLE

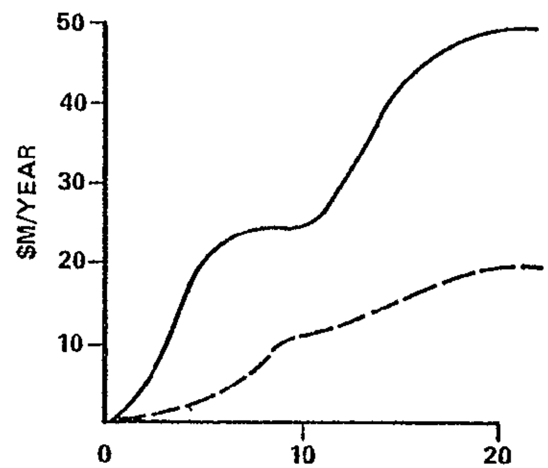
INDUSTRY: TRAVEL

USE. LONG DISTANCE TRANSPORTATION

- UTILIZE LOW COST SHUTTLE SYSTEM FOR LONG DISTANCE COMMERCIAL TRAVEL.

PASSENGERS

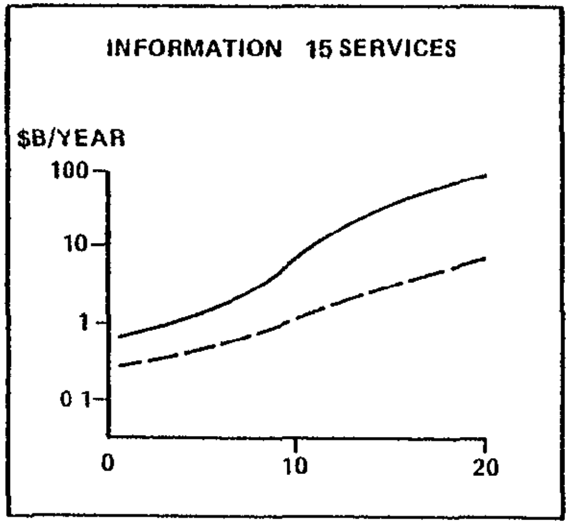


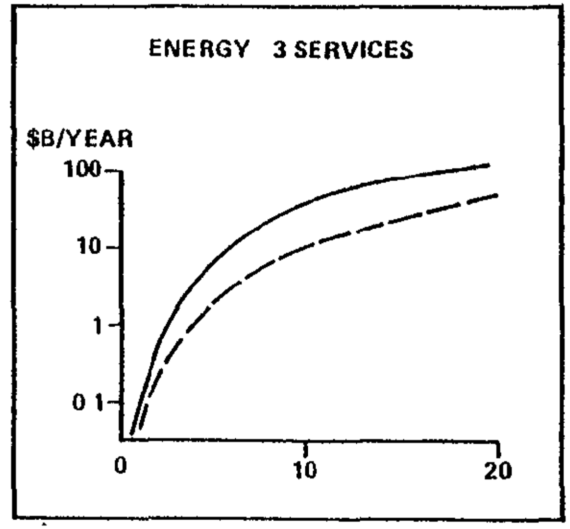


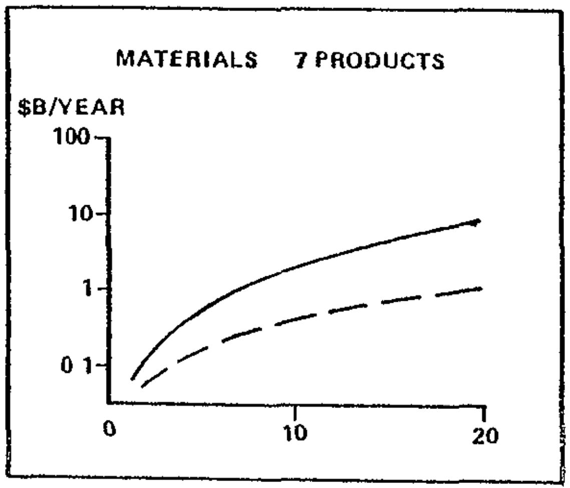
SUMMARY OF MARKET SURVEYS

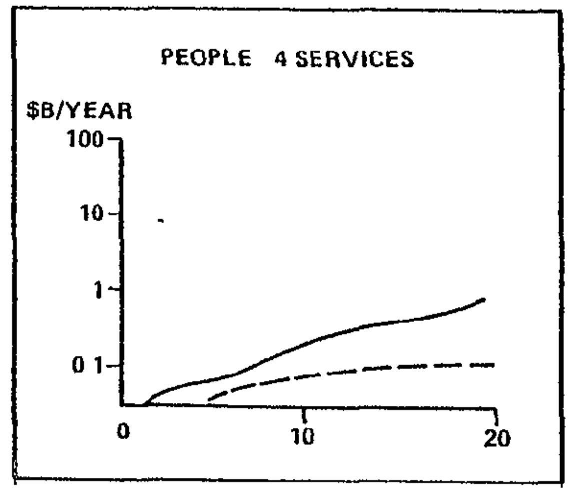
The total of best case and worst case for each activity are summed directly and presented in these comparative plots. All summations are done based on an arbitrarily common year zero in order to show relative magnitudes. The year of initial penetration, rate of growth, and final sturation level are all scenario dependent for both products and services. Therefore, direct summation of the various totals here is not appropriate.

SUMMARY OF MARKET SURVEYS









REVENUE COMPARISON - BASELINE SCENARIO

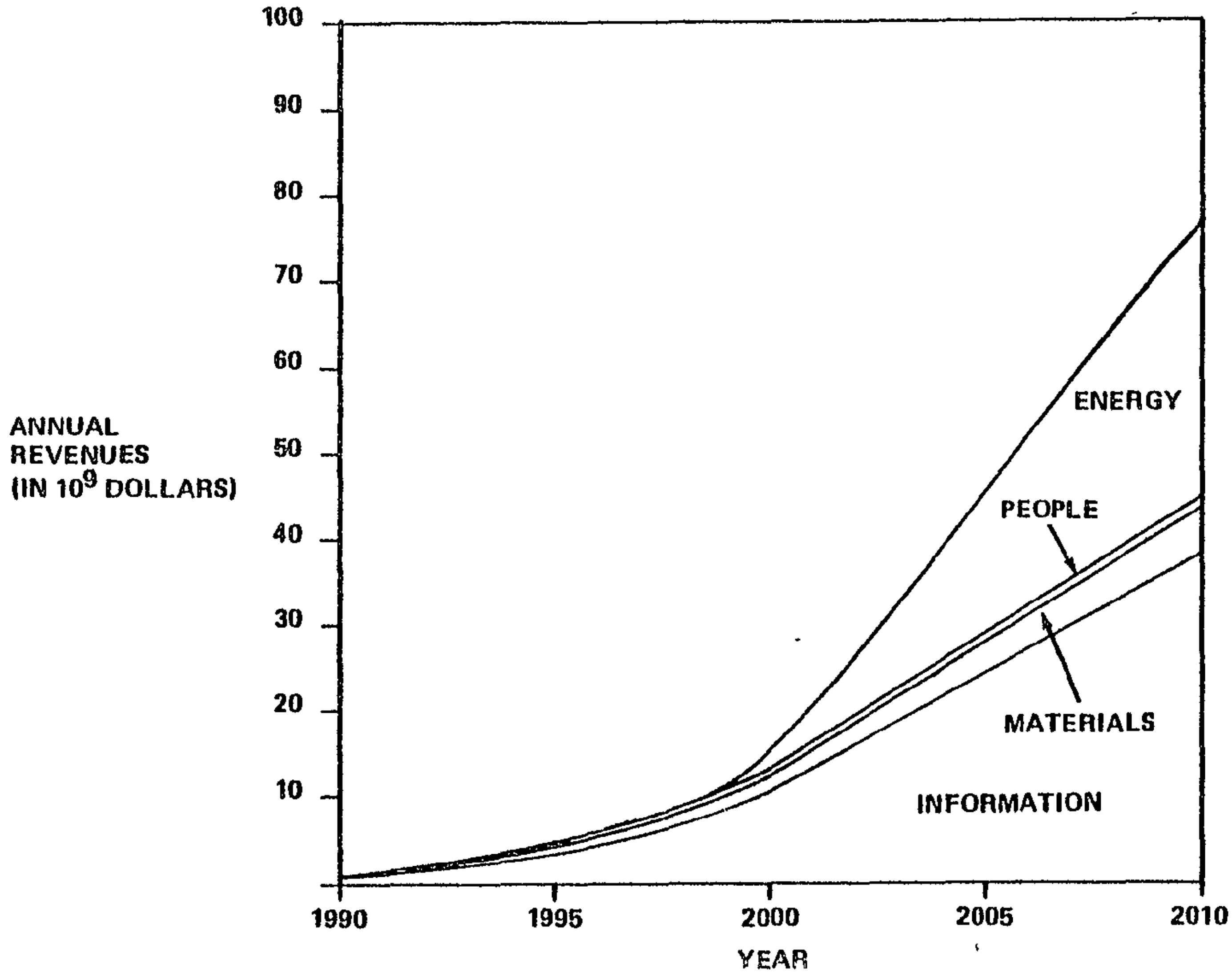
- Information services potentially have revenues similar to an extensive satellite power system program.

- Materials activities projections are sensitive to transportation costs, and can exceed \$20B/year by 2010. A conservative estimate of about \$5B/year is shown here.

- People activities are a distant fourth in revenue potential, but may be important psychologically.

Acceleration of the timing for revenues is very possible in a more aggressive scenario. The numbers illustrated here were derived in the light of the Baseline Scenario extrapolative assumptions.

REVENUE COMPARISON – BASELINE SCENARIO



PROGRAM DEVELOPMENT - METHODOLOGY

The eleven future scenarios were aggregated into six programs based on programmatic similarities. The six programs span a spectrum from optimistic upside to pessimistic downside. Variation due to the biggest single alternative, satellite power system, is shown by the baseline versus the NO SPS alternative program.

The activities corresponding to the major products and services are time sequenced based on the drivers from the future scenarios to produce the programs. The supporting systems required for the scheduled activities are added to complete the program The programs are analyzed for implications for near term system requirements and timing as well as investments and revenues.

Investments are developed for each program from design, development test and evaluation (DDT&E), and hardware production as well as space transportation costs. Public funding is assumed for DDT&E and early transportation costs. Private funding is assumed for production and launch of operational hardware. Benefits include direct revenues generated by the space activities as well as projected jobs, taxes, exports, etc.

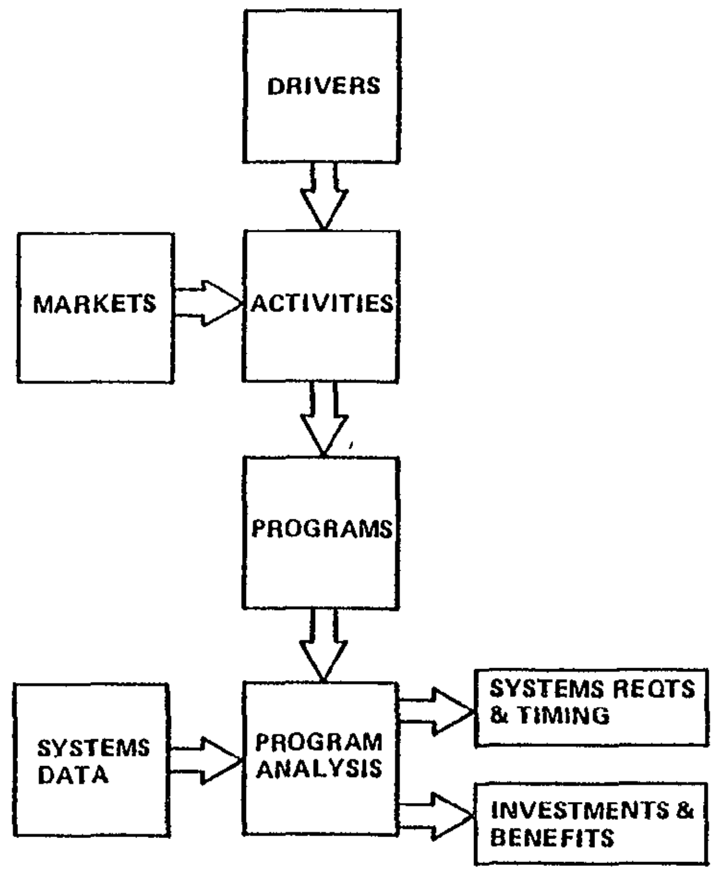
PROGRAM DEVELOPMENT

METHODOLOGY

CONSOLIDATION

11 SCENARIOS → 6 PROGRAMS

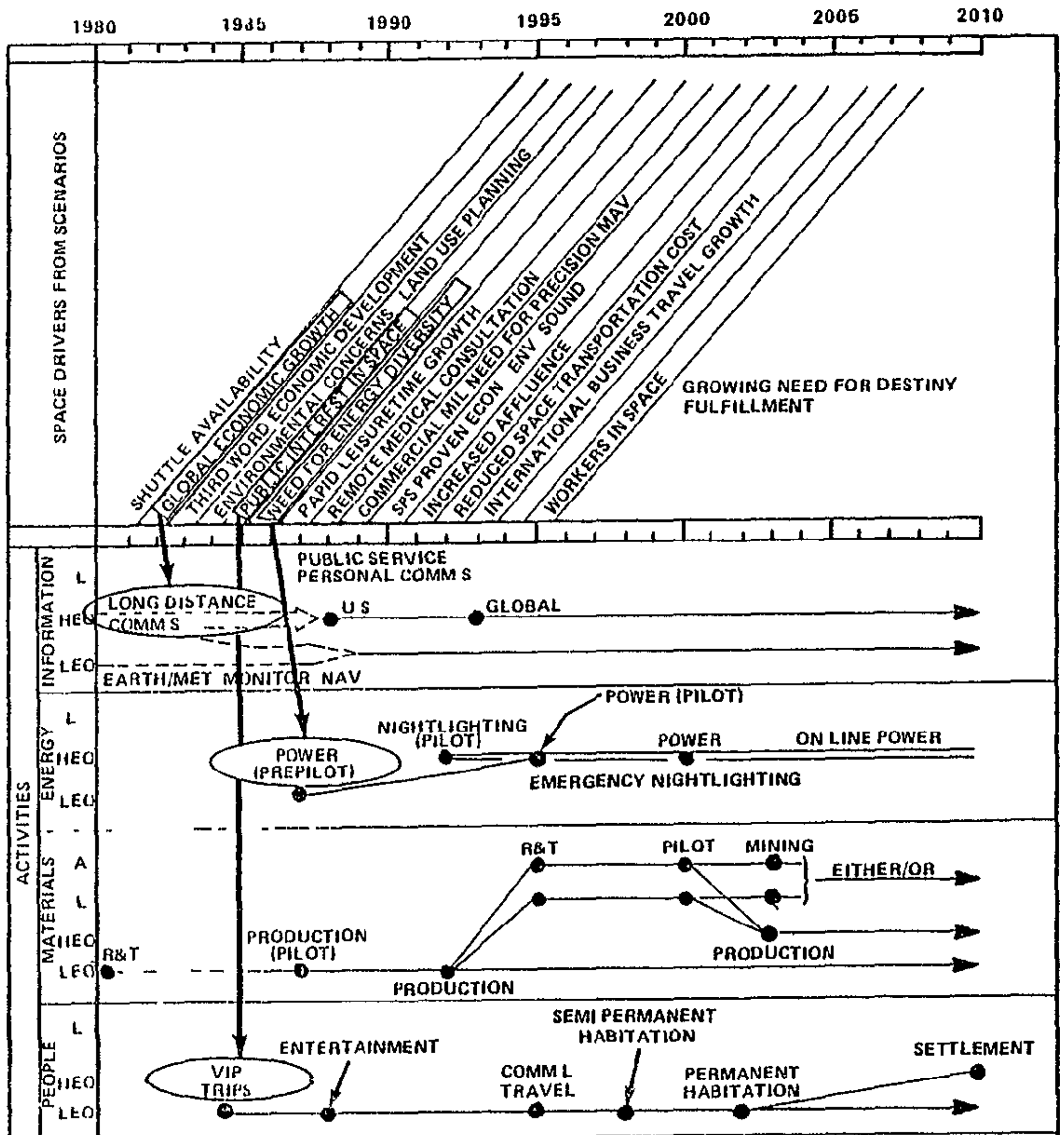
Foreign Challenge Commitment to Space Longevity Breakthrough	Upside
Cooling of N Hemisphere	Climatic Crisis
Space Entrepreneurs	Commercial
Baseline Critical Materials Shortage Ecological Catastrophes	Baseline
Energy Breakthrough	No SPS
Disenchantment with Space Collapse of Debt Structure	Downside

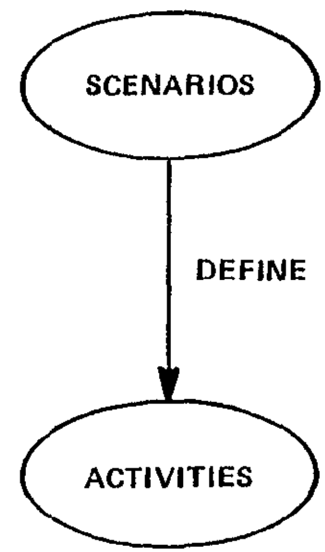


SCENARIO DRIVERS FOR SPACE ACTIVITIES

Space drivers from the baseline scenario lead to the activities of the baseline program. Global enconomic growth leads to increased long distance communications Growing public interest in space is synergistic with VIP trips on the shuttle The need for energy diversity provides motivation for beginning a satellite power system with an early prepilot demonstration. These drivers must precede the activity by sufficient lead time.

SCENARIO DRIVERS FOR SPACE ACTIVITIES

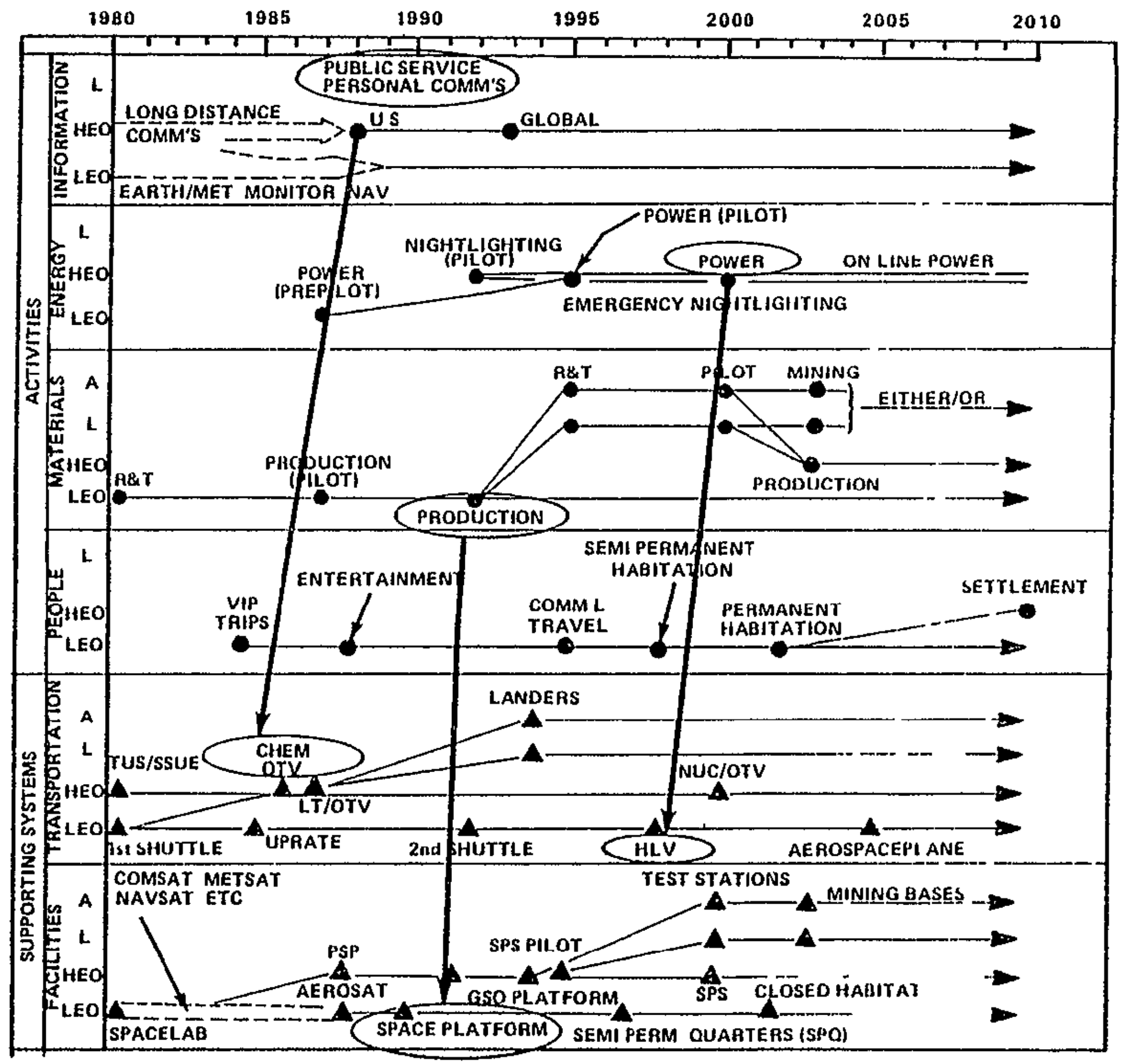


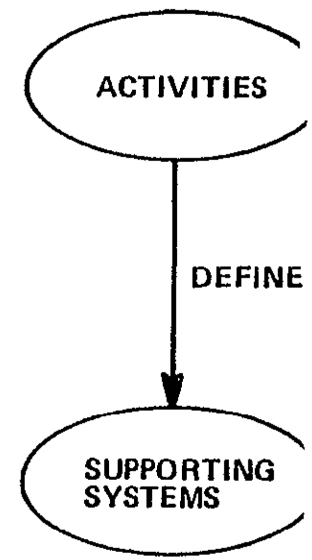


BASÈLINE PROGRAM

The program activities require supporting systems which must be started with sufficient lead time. The public services (personal communications, etc.) satellites require a means to deliver and maintain the systems in high Earth orbit -- a chemical orbital transfer vehicle. Materials production in low Earth orbit requires a facility herein called a space platform. Producing power by satellite for ground use is a massive undertaking which demands a low cost transportation system.

BASELINE PROGRAM



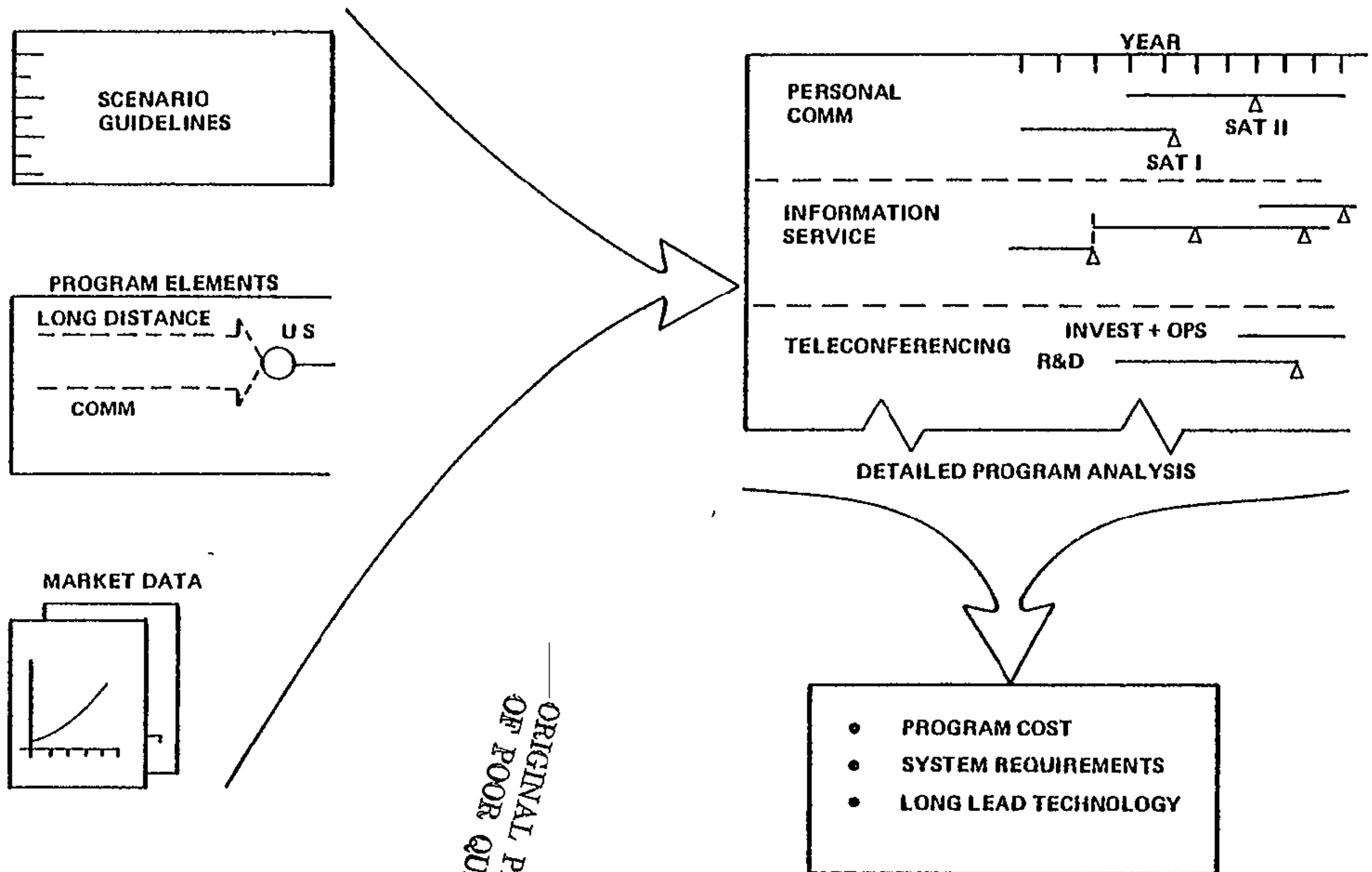


PROGRAM ANALYSIS - METHODOLOGY

The Commercial, Climatic Crisis and Upside programs were very similar to the Baseline except in timing of major space activities and magnitudes of certain activities. The largest single swinger between programs was the SPS. The impact of this was examined by detailed program analysis of the Baseline and NO SPS programs. Some examination of the cost and economics was done on the Upside Program to see what the impacts might be under the best of circumstances. This will be discussed later.

The two detailed analyses consisted of breaking the industry activities down into specific initiatives and using the scenarios and market data to size and time phase representative hardware requirements. This analysis then yielded program cost, both direct and support system requirements, and timing of technology requirements.

PROGRAM ANALYSIS – METHODOLOGY



ORIGINAL PAGE IS
OF POOR QUALITY

PROGRAM ANALYSIS - OBSERVATIONS

An overview of observations for each activity focuses on the major advantages for space, the major technical hurdles and the possible timing. Information activities have already begun with communications, observations and navigation industries However, by the mid 1980's, significantly larger systems could begin operation and expansion would then proceed rapidly. The information systems utilize the view and access offered by orbiting the Earth The major technical hurdles to their implementation are their size and power requirements as well as the need for extensive data processing to be conducted in space.

Energy activities rely mainly on the solar flux. The major technical hurdles are due to the size and mass of the systems, which leads to a requirement for lower transportation costs. Additionally, environmental issues may present significant barriers for their implementation. The timing for energy activities is viewed as after the late 1990's.

Materials activities take advantage primarly of the reduced gravity and high vacuum available in orbit In addition to demonstration of techniques, materials activities will require significant power and low cost transportation. These are envisioned to begin during the late 1980's in, perhaps, commercial batch quantities.

People activities in space use the uniqueness of space. The major technical hurdles are transportation cost and, for large scale activities, habitation facilities. These activities could be viable starting in the 1990's.

PROGRAM ANALYSIS

OBSERVATIONS

ACTIVITY	INFORMATION	ENERGY	MATERIALS	PEOPLE
MAJOR SPACE ADVANTAGE	• VIEW • ACCESS	• SOLAR FLUX	• LOW 'G' HIGH VAC • HIGH VAC	• UNIQUENESS
MAJOR TECHNICAL HURDLES	• SIZE 10–100 METER ANTENNA • POWER 21 KW – 10,000 KW • DATA PROC	• SIZE/MASS OF SYSTEM ~ 10^4 MW ~ 10^5 TONS ~ $\$10^{10}$ • TRANSPORT COST $<$ \$20/LB LEO • ENVIRONMENT ISSUES	• PROOF OF THEORY • PRODUCTION DEVELOPMENT HUNDREDS OF POUNDS PER DAY • POWER 10 KW – 10,000 KW CONTINUOUS • TRANSPORT COST $<$ \$100/LB LEO	• TRANSPORT COST \$25/LB OR LESS • HABITATION
TIMING FOR SIGNIFICANT REVENUES	• PRESENT $>$ \$300 M/YR • 1985 + RAPID EXPANSION	• 1996 +	• 1987 +	• 1990 +

PROGRAM ANALYSIS - COST AND REVENUES
BASELINE PROGRAM

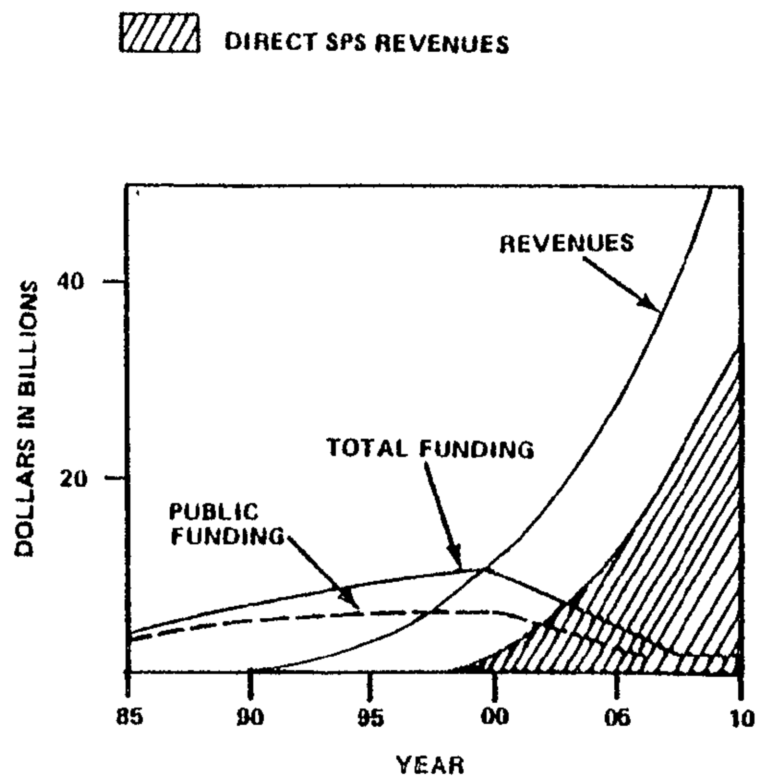
A comparison of annual revenues and expenditures and cumulative revenues and expenditures was made where required funding included DDT&E for systems and production and launch of the hardware. Revenue predictions came from the market surveys conducted A full definition of all operations and ground segment costs were not addressed. All DDT&E was assumed to be paid for public funding, whereas profit making production hardware and launches, were assumed to be commercial. This allows certain implications and conclusions to be drawn on this program. Particularly, it is noted that the SPS, which required substantial early funding, will tend to push the total program break even into the 2010 time period with return on investment (ROI) delayed until afterwards This is not unexpected since the SPS would by necessity be a long payback investment The cross-hatched area represents SPS revenues

The programs related to other scenarios all show the same basic trends with some shifting and swelling of funding and revenue curves Peak yearly funding for the Baseline Program would be on the order of $10B.

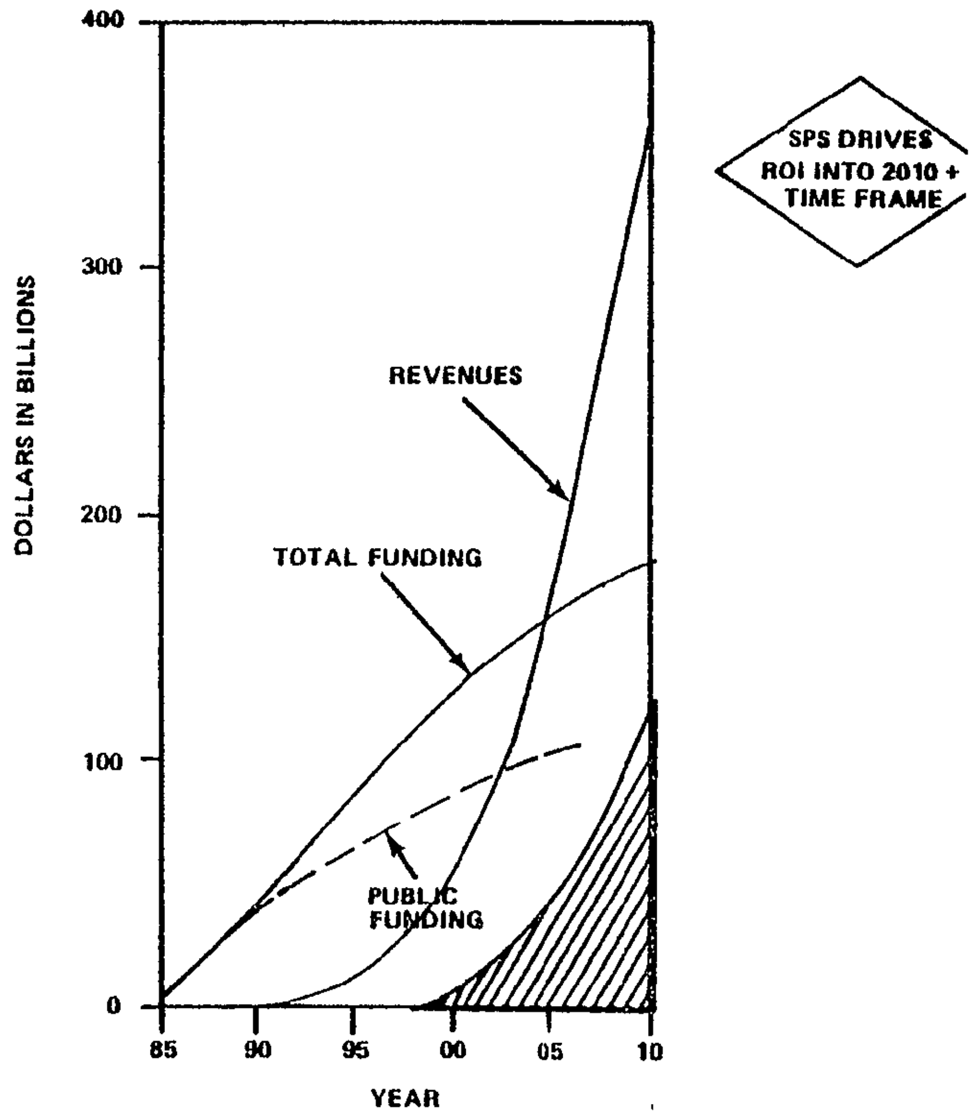
PROGRAM ANALYSIS — COST AND REVENUES

BASELINE PROGRAM

- 1977 DOLLARS
- SPACE SEGMENT COST ONLY



ANNUAL REVENUES & EXPENDITURES



CUMULATIVE REVENUES & EXPENDITURES

PROGRAM ANALYSIS - COST AND REVENUES

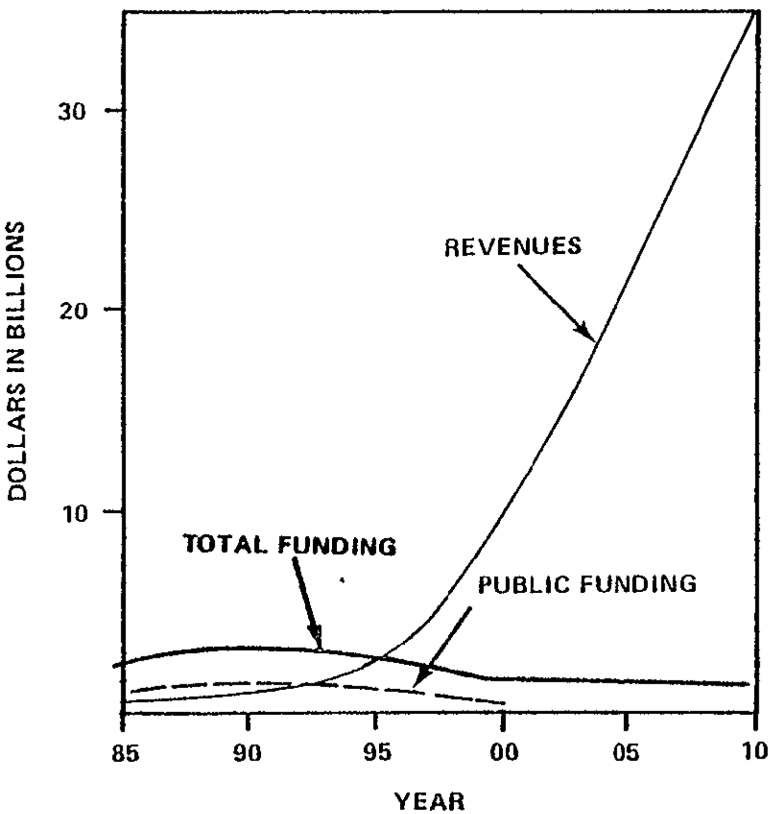
NO SPS PROGRAM

This is the major alternative to the Baseline containing an SPS. The direct effect of the SPS including extraterrestrial material acquisition, etc. can be seen by comparison with the Baseline. A comparison of annual revenues and expenditures and cumulative revenues and expenditures was made where required funding included DDT&E for systems and production and launch of the hardware. Revenue predictions came from the market surveys conducted As with the baseline, operations and ground segment costs were not included As indicated on the charts, information systems look highly attractive for good ROI and early payback. Peak funding would appear to be less than $2 billion.

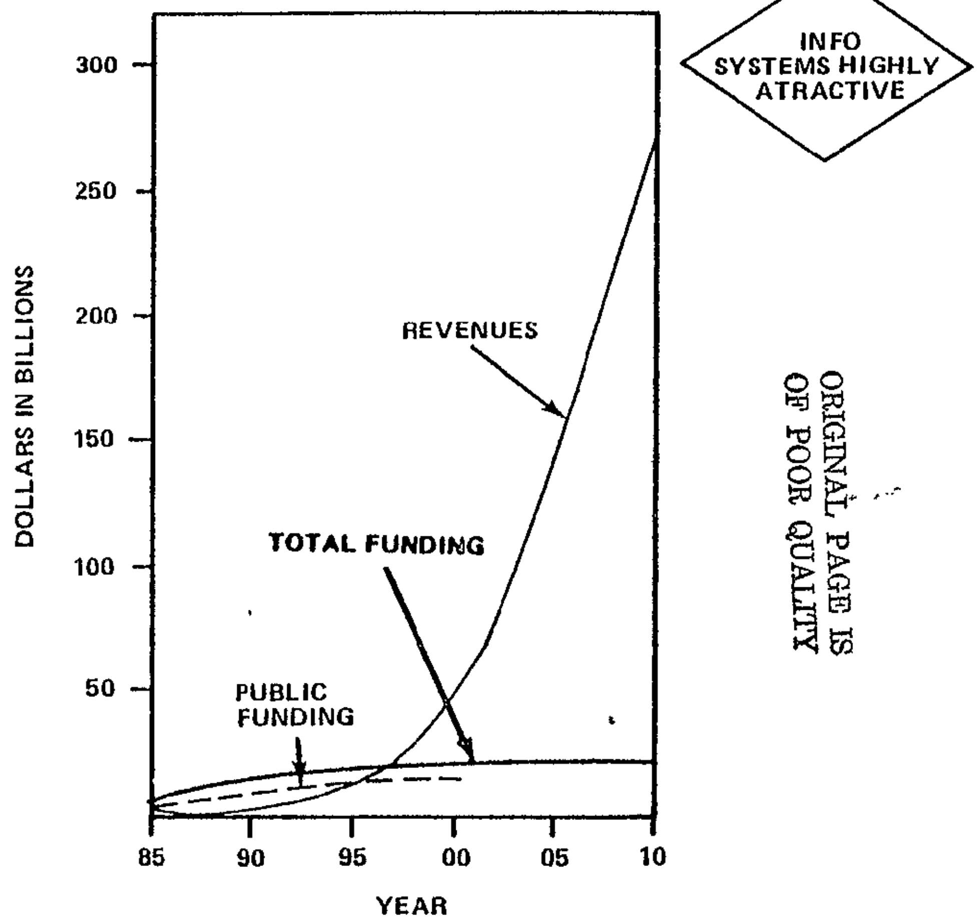
PROGRAM ANALYSIS COST AND REVENUES

NO SPS PROGRAM

- 1977 DOLLARS
- SPACE SEGMENT COST ONLY



ANNUAL REVENUES & EXPENDITURES



CUMULATIVE REVENUES & EXPENDITURES

ORIGINAL PAGE IS OF POOR QUALITY

PROGRAM ANALYSIS - BENEFITS

An analysis of the benefits of investments and revenues in terms of jobs, taxes, GNP and a number of qualitative factors was conducted for the Baseline, Upside, and NO SPS programs. Relatively conservative assumptions were made on labor intensity and indirect mulipliers for determination of jobs and taxes generated. The 1985 benefits are derived from the government funding projected for each program during the developmental phases. The 2010 benefits are based purely on commercial revenue projections with no government funding involved.

PROGRAM ANALYSIS

BENEFITS

	NEW JOBS *			TAXES GENERATED*		
	NO SPS	BASELINE	UPSIDE	NO SPS	BASELINE	UPSIDE
1985	15,000	100,000	120,000	$ 100 M	$ 800 M	$ 1,000 M
2010	1,000,000	1,900,000	3,800,000	$ 10,000 M	$ 20,000 M	$ 40,000 M

*DIRECT ONLY. TOTAL IMPACT MUCH GREATER.

EXPORTS
COMM/INFO TECHNOLOGIES
SPACE SYSTEMS
SYSTEMS MANAGEMENT
LAUNCH SERVICES
NEW MATERIALS
ENERGY
ENERGY SYSTEMS

OTHER

GNP IMPACT IN 2010 = $200B – $800B
QUALITY OF LIFE IMPROVED
COUNTLESS LIVES SAVED
NATIONAL PRIDE ENHANCED
OPTIONS FOR UNFORESEEN FUTURES
INCREASES IN SCIENTIFIC KNOWLEDGE

AGENDA CONCLUSIONS

In this concluding section specific recommendations are made keyed mainly to the near term hardware considerations.

AGENDA

INTRODUCTION

- OBJECTIVES
- APPROACH
- TEAM

STUDY OVERVIEW

- FUTURE SCENARIOS
- COMPILING CANDIDATES
- TERRESTRIAL ALTERNATIVES
- MARKET SURVEYS
- PROGRAM DEVELOPMENT/ ANALYSIS

CONCLUSIONS

- WHAT SHOULD NASA DO?
- WHY HURRY?
- WHAT NEXT?

WHAT SHOULD NASA DO?

This study has clearly shown that major activities with information, materials and energy in space are attractive and should be pursued. The key technologies shown must be developed to support the activities.

NASA should push the technologies leading to a low cost transportation system, large structures and power generation on orbit and orbital materials processing. The role of NASA should stress providing the required support facilities, systems and demonstration programs to prove techniques and commercial viability

WHAT SHOULD NASA DO?

THE MOST SIGNIFICANT SPUR TO U S. INDUSTRY AND U.S WORLD TECHNICAL LEADERSHIP WILL RESULT FROM NASA DEVELOPING THE FOLLOWING KEY TECHNOLOGIES

- LARGE INFORMATION SYSTEMS
  - STRUCTURES – LARGE ANTENNA OF 10M TO 200M DIAMETER
  - POWER -- 20 KW TO 10,000 KW
  - DATA PROCESSING – 100 TO 1000 TIMES PRESENT RATE
  - TRANSPORTATION TO HIGH ORBIT – ROUTINE FOR MAINTENANCE, REPAIR
- MATERIALS SPACE PROCESSING
  - LABORATORY DEMONSTRATION – GOAL ORIENTED SPAR, SPACELAB
  - PROTOTYPE PRODUCTION – 10 TO 100 POUNDS PER DAY ON SOME PRODUCTS
  - ORBITAL SUPPORT SYSTEMS – POWER, STRUCTURE, STABILITY
  - LOW COST TRANSPORTATION TO LOW ORBIT – $<$ \$100/POUND TO REALLY OPEN MARKET
- LARGE ENERGY SYSTEMS (USE IN SPACE, BROADCAST TO EARTH)
  - STRUCTURES – 0 5 KM TO 15 KM
  - POWER CONDITIONING – 100 KW TO 10 GW
  - LOW COST TRANSPORTATION TO HIGH ORBIT – MINIMUM FEASIBLE COST

WHY DEVELOP THE KEY TECHNOLOGIES?

The projected benefits depend upon commercial operations that can only begin after the key technologies are available. The potential benefits are significant covering a spectrum of national concerns from jobs and balance of trade through standard of living and national pride.

WHY DEVELOP THE KEY TECHNOLOGIES?

ANALYSIS OF FUTURE SCENARIOS, MARKETS AND RESULTANT PROGRAMS SHOW THAT THE RESULT WILL BE.

- MILLIONS OF JOBS CREATED
- SIGNIFICANT NATIONAL ECONOMIC GROWTH
- ASSURANCE OF A LONG TERM FAVORABLE BALANCE OF TRADE
- INCREASED NATIONAL AND WORLD-WIDE STANDARDS OF LIVING
- AN ENRICHMENT OF NATIONAL PRIDE AND ASPIRATIONS
- AN INVALUABLE OPTION BANK FOR RESPONDING TO UNFORESEEN FUTURE EVENTS
- INCREASES IN KNOWLEDGE PROBABLY UNPARALLELED IN THE HISTORY OF CIVILIZATION

WHY HURRY?

"The future belongs to those who create it!"

With the shuttle, we have the basis for space industrialization. We can utilize our lead by proper planning and timely implementation. The alternatives are clear---expanding the U.S. economy or growing international competition.

WHY HURRY?

- THE REVENUE POTENTIALS EXIST TODAY —— WE ONLY LACK THE SYSTEMS
- ALL INDUSTRIES EXAMINED ARE EXPORTABLE —— THE SOONER THEY ARE AVAILABLE, THE SOONER WE REAP THE BENEFITS
- NEAR TERM EXPENDITURES WILL CREATE JOBS, SPUR THE ECONOMY, AND BE NON-INFLATIONARY WHILE CREATING THE FUTURE
- THE TIMES ARE RIGHT —— IF WE WAIT THEY MAY NOT BE.
- WE CAN NOT EXPLOIT THE SHUTTLE IF WE DON'T KNOW WHERE WE ARE GOING.
- SERIOUS INTERNATIONAL COMPETITION IS RAPIDLY BUILDING

WHAT NEXT?

We should begin actively supporting space industrialization by producing a major space power system, initiating the development of systems to support orbital manufacturing and developing large information systems. Substantial space power is needed for almost any industrialization. Materials manufacturing in orbit will require considerable demonstration and supporting systems. Large space information systems look the most commercially viable but the orders-of-magnitude scale-up needed will require demonstration and legal constraints (e g., frequency allocations) may pose the biggest hurdles.

WHAT NEXT?

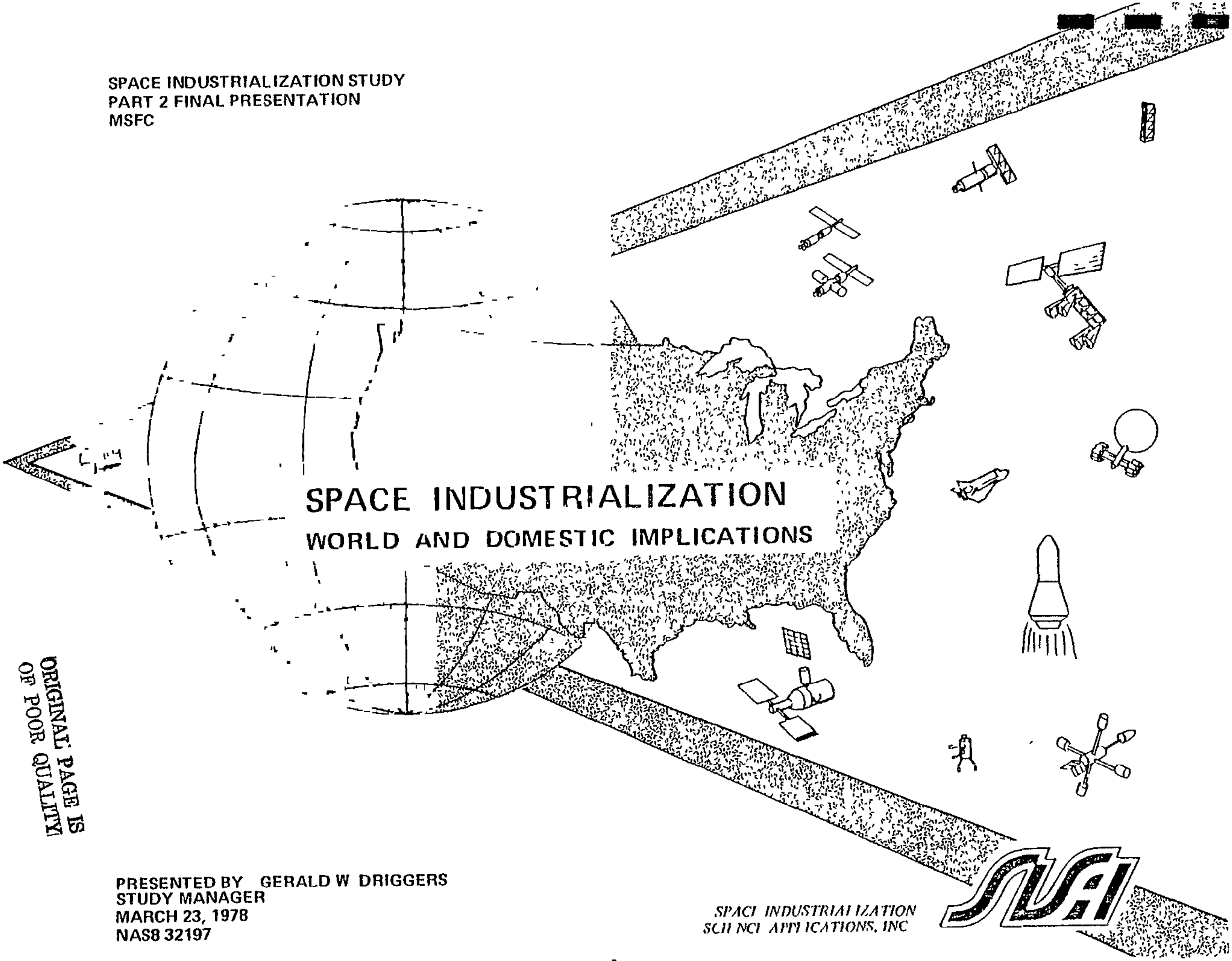
- PRODUCE POWER ON ORBIT CAPABLE OF SUPPORTING AGGRESSIVE SPACE MANUFACTURING, INFORMATION SYSTEMS AND SOLAR POWER DEMONSTRATION PROGRAMS AS SOON AS POSSIBLE!
- INITIATE RESEARCH, TECHNOLOGY AND SYSTEM DEVELOPMENT PROGRAMS TO ALLOW INTRODUCTION OF LOW COST TRANSPORTATION AND FULL ORBITAL SUPPORT FOR MANUFACTURING IN 1987
- INITIATE RESEARCH, TECHNOLOGY AND SYSTEM DEVELOPMENT PROGRAMS REQUIRED TO SUPPORT INTRODUCTION OF LARGE, HIGH TECHNOLOGY INFORMATION SYSTEMS AS SOON AS POSSIBLE

☆U S GOVERNMENT PRINTING OFFICE 1977—740 049/369 REGION NO 4

APPENDIX B

PART TWO FINAL PRESENTATION

SPACE INDUSTRIALIZATION STUDY
PART 2 FINAL PRESENTATION
MSFC



SPACE INDUSTRIALIZATION
WORLD AND DOMESTIC IMPLICATIONS

PRESENTED BY GERALD W DRIGGERS
STUDY MANAGER
MARCH 23, 1978
NAS8 32197

SPACE INDUSTRIALIZATION
SCIENCE APPLICATIONS, INC

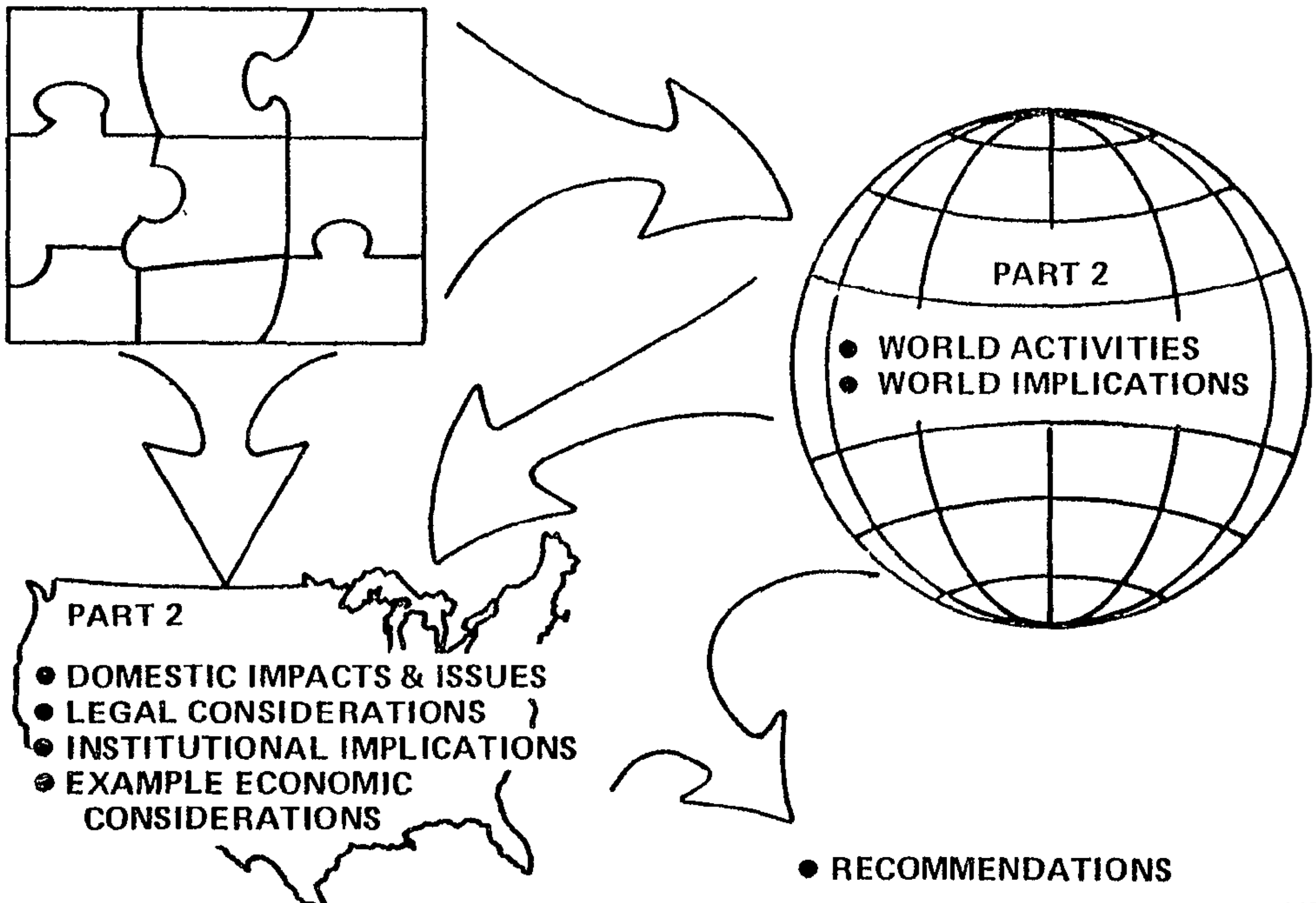
SPACE INDUSTRIALIZATION STUDY EVOLUTION

This is the summation of efforts and results from Part 2 of the Space Industrialization Study conducted for NASA/MSFC by SAI under contract NAS8-32197. Presentation of the results of Part 1 of the study were previously presented in a similar format.

Whereas Part 1 of the study was concerned with defining and scoping SI, Part 2 was directed toward issues related to concept implementation both on the basis of the world and the United States. From the totality of considerations has been drawn a set of basic recommendations for action and further study at various levels of technology and programming.

SPACE INDUSTRIALIZATION STUDY EVOLUTION

PART 1
DEFINITION & OVERVIEW

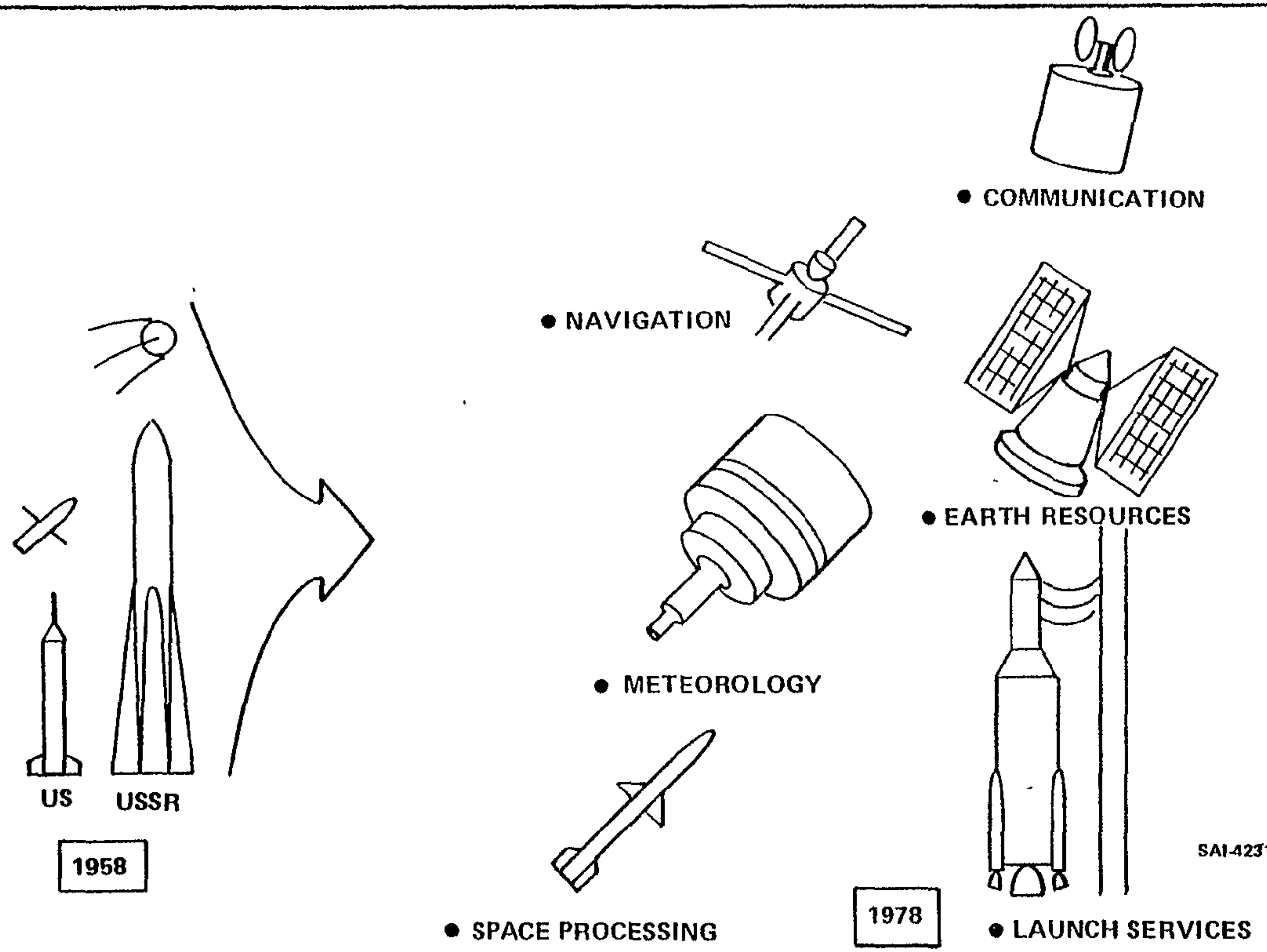


SAI-4230

SPACE INDUSTRIALIZATION - 20 YEARS LATER

From military and scientific beginnings some twenty years ago (October 1957 for Sputnik, January 1958 for Explorer) there has evolved a broad and complex industrial base in space. The activities range from basic research in the space processing of materials to the fully operational information transfer systems. The worldwide gross annual revenue now exceeds one billion dollars in sales of services alone. Current published projections indicate that revenues from services by 2000 may reach ten to twenty billion dollars given only minor extrapolations of present technology. With technology advancements in power, structures, transportation, materials processing, frequency use and data handling our study indicates that the potential can be several times that revenue amount. Of the four general categories of space industrialization (Information Services, Products, Energy, People in Space) the area nearest maturity is Information Services as reflected on this chart. New technologies will be necessary to open up new markets in these services also, however.

SPACE INDUSTRIALIZATION – 20 YEARS LATER



WORLDWIDE SI CAPABILITY SUMMARY

The worldwide interest in SI is reflected by the number of countries and agencies that are actively participating at present. This is characterized in this chart by summarizing capabilities both previously demonstrated and currently being developed that relate specifically to space industrialization. Although manned capabilities are dominated by the USA and USSR the fruits of SI technologies are being used broadly as demonstrated by the first two columns. Also significant is the extensive involvement of nations and international organizations in unmanned activities. This would indicate that the unique technologies most significant to US future exploitation in SI would be those associated with manned space flight, particularly shuttle related capabilities.

The bottom line (both figuratively and literally) of this chart carries a significant message: space industrialization is a strong, viable international and multinational endeavor.

WORLDWIDE SI CAPABILITY SUMMARY

	GENERAL				UNMANNED				MANNED				UNMANNED			MANNED			
NATION \ CAPABILITY	DATA HANDLING	GROUND STATION(S)	LAUNCH FACILITY (S)	SUBORBITAL LAUNCH	LEO LAUNCH	LEO RETURN	GSO LAUNCH	ORBITAL RENDEZVOUS	LEO LAUNCH	LEO OCCUPANCY	ORBITAL RENDEZVOUS	ORB PROPELLANT TRANS	EARTH OBSERVATION	COMMUNICATIONS	NAVIGATION	TEST & EXPERIMEN.	MAINT. & REPAIR	REMOTE CONTROL	MATERIALS PROCESSING
UNITED STATES	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
USSR	X	X	X	X	X	X	X	Ⓧ	Ⓧ	Ⓧ	Ⓧ	Ⓧ	X	X	X	Ⓧ	Ⓧ	X	X
CHINA (PR)	X	X	X	X	X	X							X	X					
FRANCE	X	X	X	X	X	?							X	X					X
INDIA	X	X	X	X	(X)								X	X					
JAPAN	X	X	X	X	X		X							X					
ESA	X	X	X	X	(X)		(X)			(X)			X	X		(X)			X
OTHER	X	X	X	X	X								X	X				X	X
TOTAL NUMBER OF NATIONS	111	39	24	15	9	3+	4	2	2	3	2	1	7	13	2	3	2	3	5

(X) Indicates to be demonstrated by 1981. Ⓧ Indicates currently unique capability

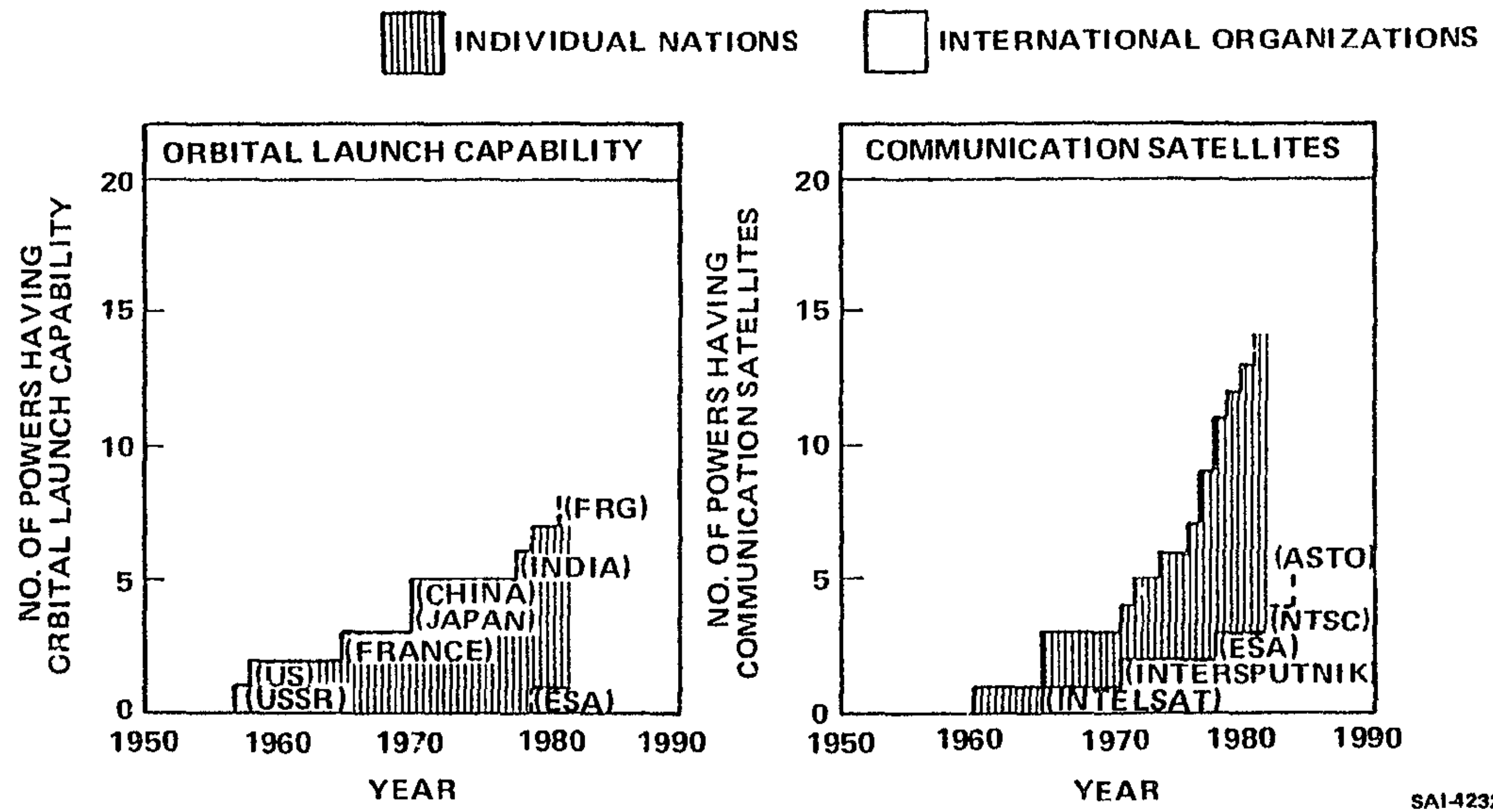
X Indicates capability has been demonstrated.

SAI 4267

INDICATIVE SI GROWTH RATES

The last chart established the status of SI in the world by illustrating current capability and utilization, all of which has evolved in the last twenty years. A related question of some immediate interest is then whether this growth continues or has it reached a plateau. This question has been addressed by examining the growth rate and plans of several "mature" SI activities. Two of these growth trends are illustrated on this chart; one is transportation capability to LEO and the second is ownership of communication satellites by nations or organizations. Launch capability continues to show a linear trend while communication satellite ownership appears to be growing exponentially. Other service applications (remote sensing, navigation, etc.) show similar trends. As an indication of how recognition times may be shortening for new SI technologies it is interesting to observe that at least five nations are now sponsoring materials space processing research with at least three organizations or nations actively conducting launches.

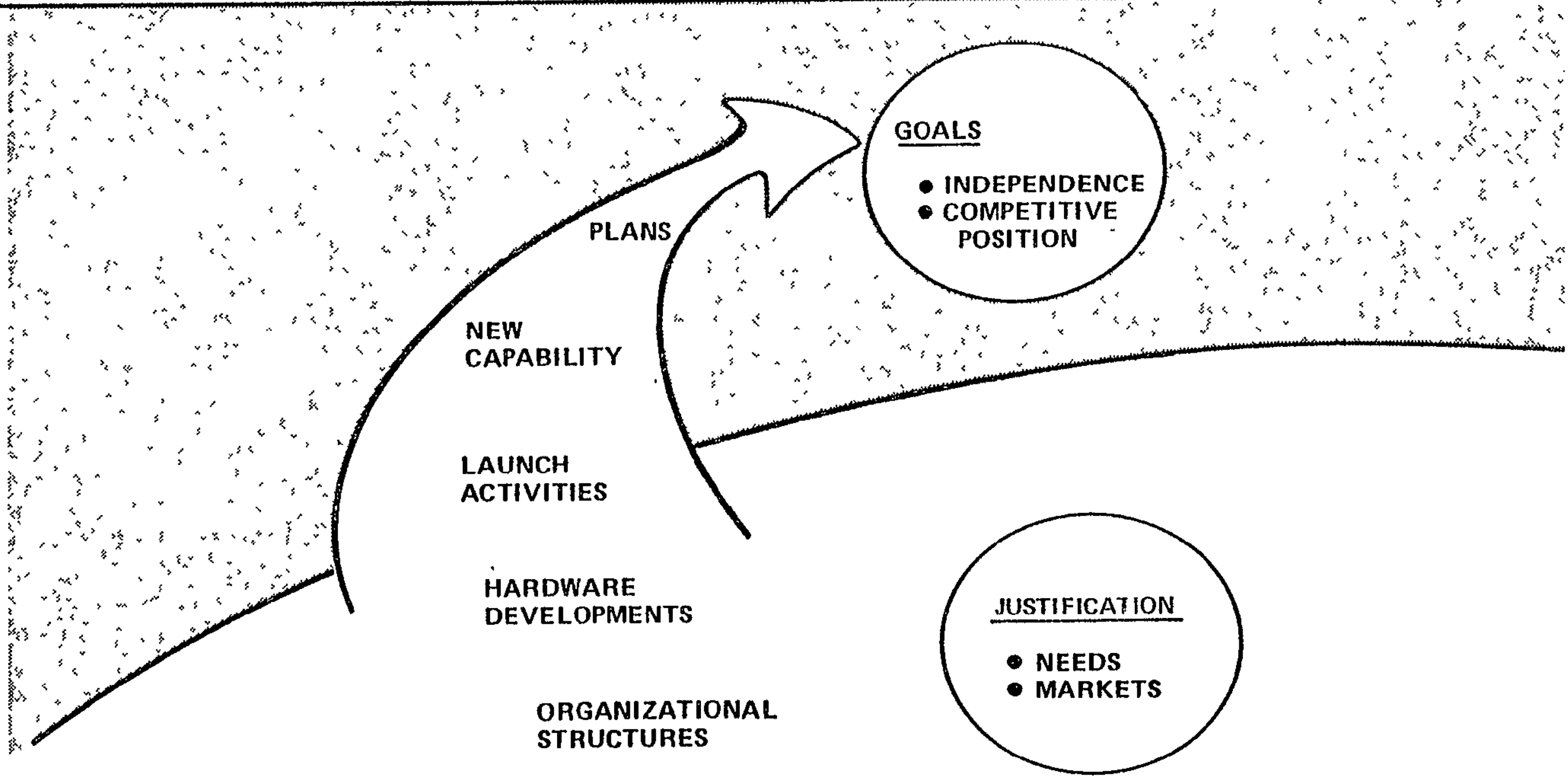
INDICATIVE SI GROWTH RATES



EVOLUTION OF WORLD SI ACTIVITIES

Why is there such extensive involvement in organizing for and implementing space industrialization in the world? In the simplest terms, it appears that needs and markets exist forming the basis for large scale international involvements. This has prompted a wide spread interest and desire for independent capabilities to utilize space and an awareness of the potential benefits from gaining and maintaining a competitive position In the free world the US will be challenged through the eighties in all technologies including those that are peculiar to manned space flight. The recent capability demonstrations of the USSR aboard Salyut 6 and the strong reports of their current development of a reusable shuttle leave no doubt that major technical achievements can be anticipated by communist bloc countries in SI throughout the eighties.

EVOLUTION OF WORLD SI ACTIVITIES



SAI-4253

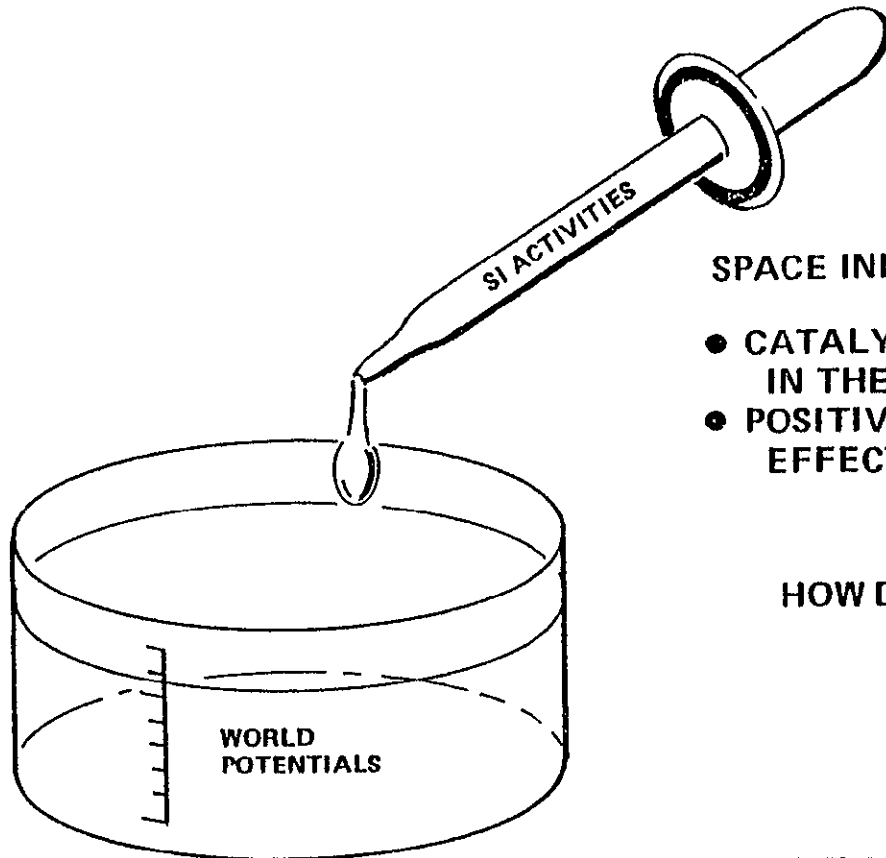
WHAT IS THE SIGNIFICANCE OF SPACE INDUSTRIALIZATION?

The key question posed here is: Will SI affect economic, social and other factors in the world in proportion to its cost (percent of gross world product for example) or can large changes be effected by relatively small SI initiatives? The goal of this examination was to determine if national, international and worldwide consequences from SI could be estimated and related back to the current and projected activities represented on the previous two charts. An inexpensive cause and effect analysis could prove very valuable in rapidly identifying those key technologies and capability needs with the largest benefit multipliers.

The approach to determining such potential cause and effect relationships involving SI on a national, international or worldwide basis was termed "impact assessment".

WORLD IMPLICATIONS

WHAT IS THE SIGNIFICANCE OF SI?



SPACE INDUSTRIALIZATION

- CATALYST OR "A DROP IN THE BUCKET"?
- POSITIVE OR NEGATIVE EFFECTS?

HOW DO WE FIND OUT?

ONE APPROACH: IMPACT ASSESSMENT

SAI-4243

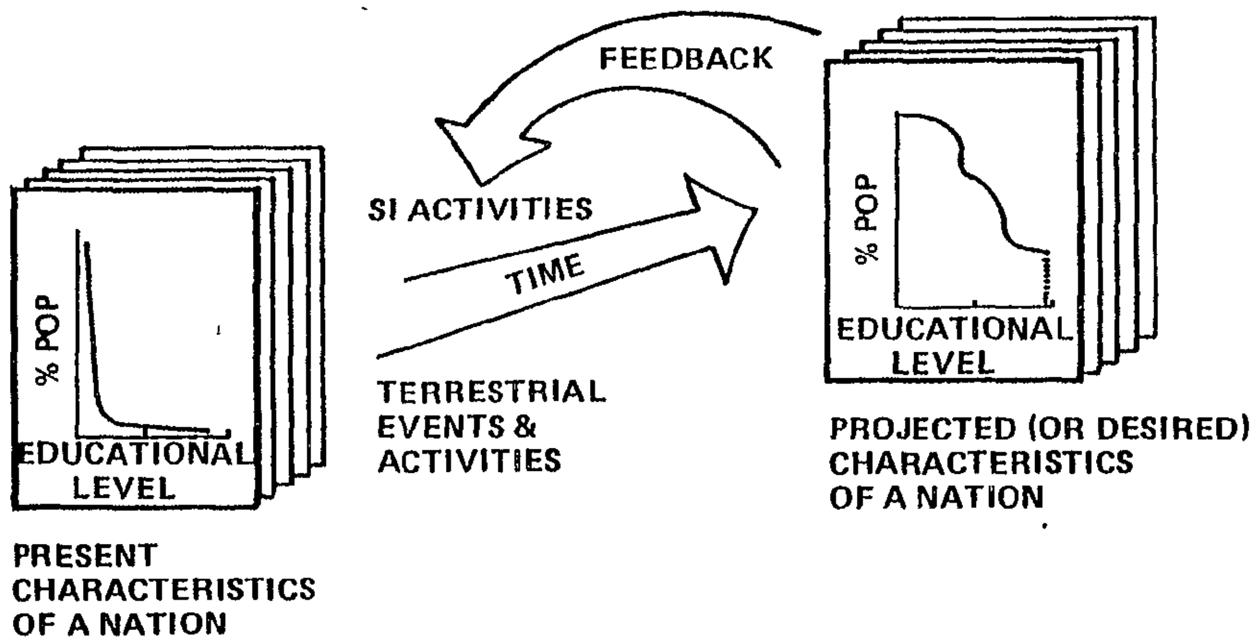
WHAT IS SI IMPACT ASSESSMENT?

As illustrated here, impact assessment involves examining the present characteristics of a nation or group of nations in detail, predicting events and activities (usually government plans and projections), superimposing SI activities and postulating their impacts and interrelationships. A feedback loop is essential to properly scope and tune the SI activities in light of their possible consequences and interrelation to terrestrial events.

The key issues associated with the broad, straight forward application of this approach were asked early in the assessment since the validity of any application of the technique would be driven by the answers.

C-2

WHAT IS SI IMPACT ASSESSMENT?



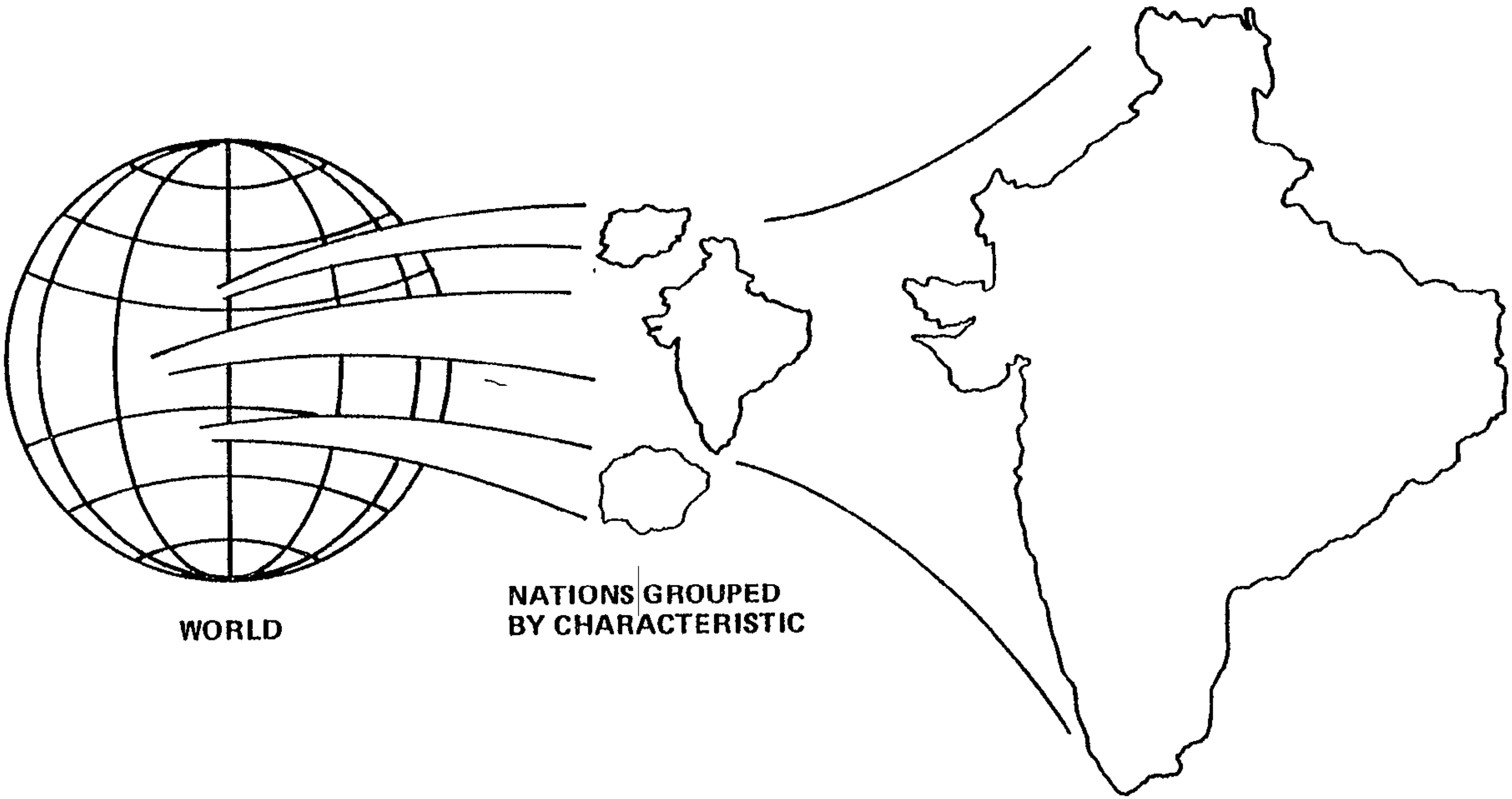
- HOW DETAILED MUST THE ASSESSMENT BE?
- CAN NATIONS BE GROUPED FOR ANALYSIS?

SAI-4233

LEVELS OF IMPACT ASSESSMENT

The potential for conducting impact assessment on the basis of national groupings by common characteristics (including the whole world) was examined after single nations had been selected. Common characteristics in geography, economics, social structures and politics were examined as key indicators leading to proper grouping.

LEVELS OF IMPACT ASSESSMENT



SAI-4234

ASSESSMENT CONSIDERATIONS

Six general characteristic areas were examined for each nation considered. Enough detail was researched in each of these to gain insight into how SI initiatives could be brought to bear on achievement of some national goal related to each area.

A qualitative assessment was made of the potential impact and the details compared among the nations. An examination of these details indicates that tailoring of SI involvement to any nation requires a highly detailed analysis and an iterative systems design approach to developing implementation plans. No valid, productive approach to impact assessment of nations by groups was postulated with the exception of environmental considerations. Although the detailed assessment will ultimately depend in many cases on the exact details of a receiving or launch site, for example, there are several generic factors which must be considered. Upper atmosphere and magnetosphere interactions are excellent examples of research areas with broad impact assessment applicability.

WORLD IMPLICATIONS

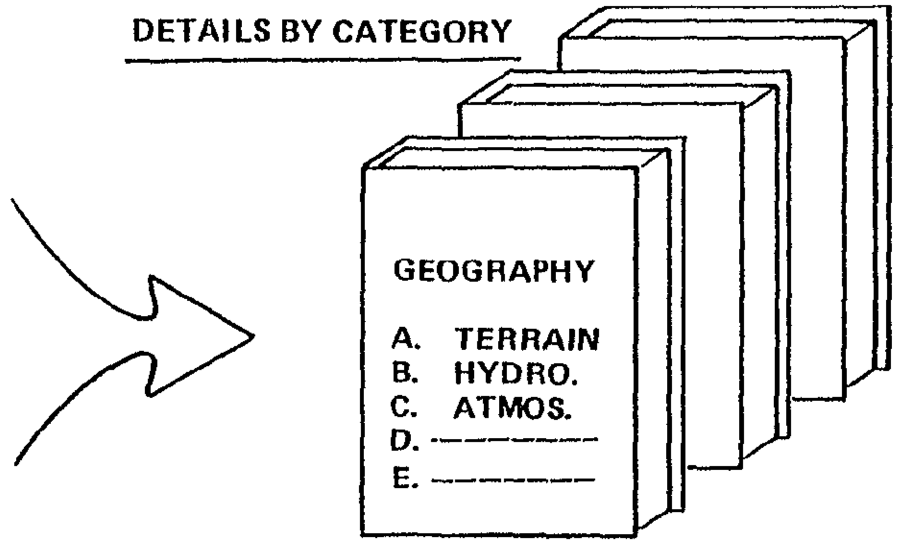
SPACE INDUSTRIALIZATION
SCIENCE APPLICATIONS, INC

ASSESSMENT CONSIDERATIONS

MINIMAL BY NATION

- GEOGRAPHY
- POPULATION
- ECONOMIC FACTORS
- SOCIETAL FACTORS
- POLITICAL FACTORS
- ENVIRONMENT

DETAILS BY CATEGORY



RESULT: GROUPED NATION ANALYSIS
NOT VALID FOR ANY CONSIDERATIONS
EXCEPT ENVIRONMENTAL

SAI-4261

EXAMPLES OF SI APPLICATIONS BY COUNTRY

The four countries examined to the greatest level of detail are shown here. They were chosen because of their commonalities and differences. The variations in applicability of SI are obvious.

One very interesting observation has resulted from this particular examination. A combination of factors determines the optimum mix of SI applications. In simplest terms, it would appear that a national with strong economic viability but in an early stage of technical and industrial development is the prime candidate as a market place for space industrialization.

EXAMPLES OF SI APPLICATIONS BY COUNTRY

CRITERIA: MUST HAVE POSITIVE EFFECT ON ANNOUNCED NATIONAL GOAL

NATION \ INDUSTRY	POCKET TELEPHONE	INFO. SERVICE	DOMESTIC COMM	DIRECT TV	NAVIGATION	EARTH RESOURCE	WEATHER	PRODUCTS	ENERGY	PER CAPITA INCOME
INDONESIA		X	X	X	X	X	X			$ 80
NIGER			X	X	?	X	?		?	100
INDIA			X	X		X	X		X	160
BRAZIL	X	X	X	X	X	X	X	?	X	750

NOTE: THE INDUSTRY LIST IS MEANT TO BE EXEMPLARY, NOT INCLUSIVE.

SAI-4235

FINDINGS

The findings discussed on the past several charts are summarized here.

WORLD IMPLICATIONS

FINDINGS

- EVERY NATION ON EARTH PROBABLY HAS A MARKET FOR SOME FORM OF SPACE INDUSTRY SERVICE OR PRODUCT.
- AN OPTIMUM MIX OF MANY FACTORS, NOT ECONOMIC DEVELOPMENT ALONE, DETERMINES THE BREADTH AND DEPTH OF SI MARKET POTENTIALS.
- INTEGRATION OF AND IMPACT ASSESSMENTS FOR SI MUST BE DONE NATION BY NATION IN A HIGHLY DETAILED FASHION TO YIELD VALID DATA.
- GENERIC ENVIRONMENTAL IMPACT ASSESSMENT CAN BE DONE TO SUPPORT U.S. WORLD MARKETING IN SI.

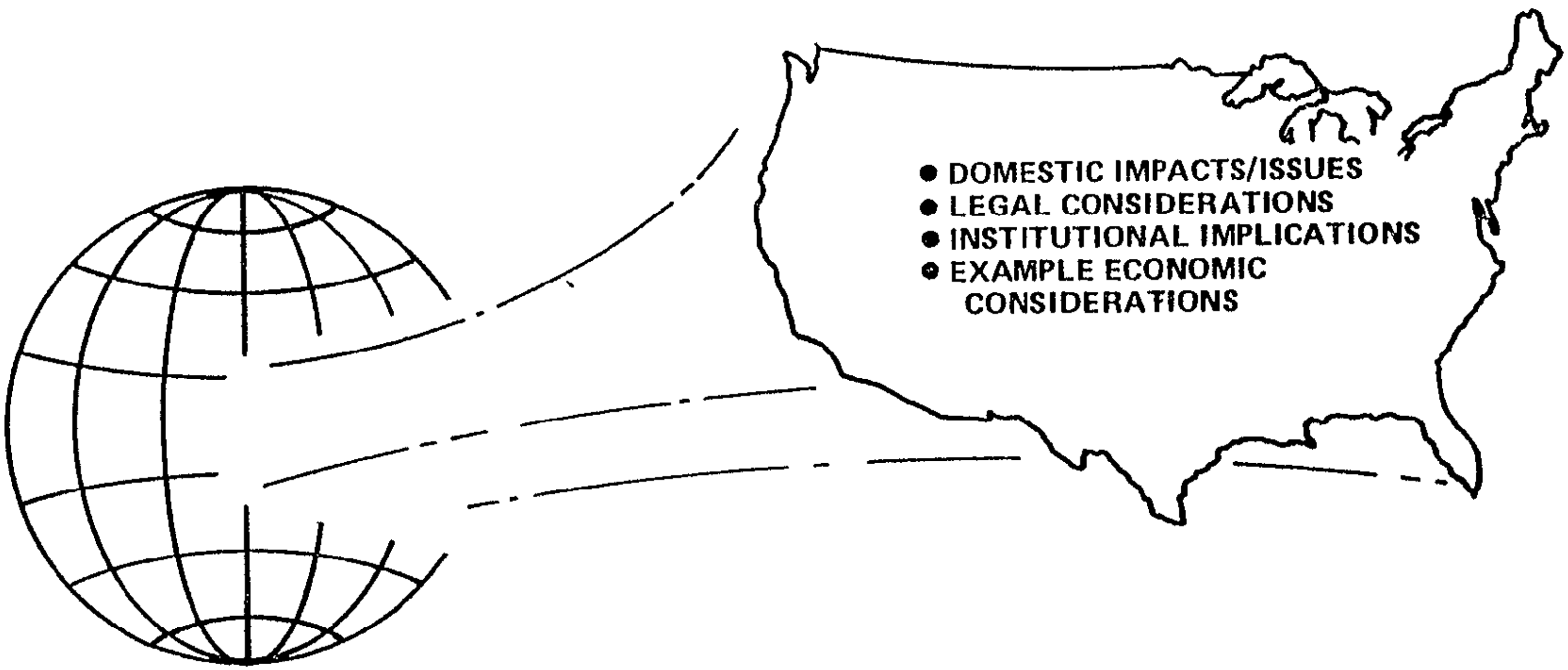
SAI-4236

UNITED STATES DETAILED ASSESSMENT

For very pragmatic reasons (our country, more plentiful data, etc.) the United States was examined in substantially greater detail than any other nation. The four general categories of examination shown on the map will be used to outline this portion of the briefing.

UNITED STATES DETAILED ASSESSMENT

A MORE DETAILED ASSESSMENT OF ONE NATION – THE UNITED STATES



SAI-4237

IMPACTS/ISSUES IDENTIFIED IN PART 1

Those areas which were identified in Part 1 as key impacts and issues relative to the US and SI are shown here. As illustrated, Part 2 of the study was partially devoted to refinement and quantification of these postulated impacts and issues. Considerable additional work needs to be done in all areas but particularly in those not examined in this study.

DOMESTIC IMPACTS/ISSUES

SPACE INDUSTRIALIZATION
SCIENCE APPLICATIONS, INC

IMPACTS/ISSUES IDENTIFIED IN PART 1

IDENTIFIED IN PART 1

IMPACTS

- ECONOMICS
  - REVENUES, TAXES, GNP
- JOBS
- BALANCE OF TRADE

0 ENERGY
0 SCIENTIFIC KNOWLEDGE
0 SOCIAL INSTITUTIONS
0 OPTIONS FOR UNFORESEEN FUTURES

ISSUES

- INDUSTRY INVOLVEMENT
- GOVERNMENT ROLES

REFINED IN PART 2

SAI-4255

EMPLOYMENT AND ECONOMY IMPACTS

Projections of impacts to new job creation, tax generation, GNP contribution and balance of trade based on expenditure requirements and revenue projections were made for two possible future SI scenarios ("plans"). Plan A included an all-up commercial SPS program whereas Plan C included most other initiatives but no SPS. In both cases almost all of the 1985 funding was by government whereas by 2010 the case flow was provided almost 100% by projections of revenue potentials and investments. All indications are that multiplying effects in the U. S. from SI investments will be very large both nationally and internationally. The most obvious implication is that of continued economic growth well into the next century with its beginnings found in SI investments in the 1980's.

SPACE INDUSTRIALIZATION
SCIENCE APPLICATIONS, INC

EMPLOYMENT & ECONOMY IMPACTS

	NEW JOBS*		TAXES GENERATED*	
	PLAN A (SPS)	PLAN C (NO SPS)	PLAN A (SPS)	PLAN C (NO SPS)
1985	100,000	15,000	$800M	$100M
2010	1,900,000	1,000,000	$20,000M	$10,000M

*DIRECT ONLY. TOTAL IMPACT MUCH GREATER. U.S. MARKETS ONLY.

OTHER IMPACTS

GNP CONTRIBUTION IN 2010 (1976 DOLLARS) = $200B TO $800B
BALANCE OF TRADE IMPACT (1976 DOLLARS) = +$10B TO $50B IN 2010

SAI-4252

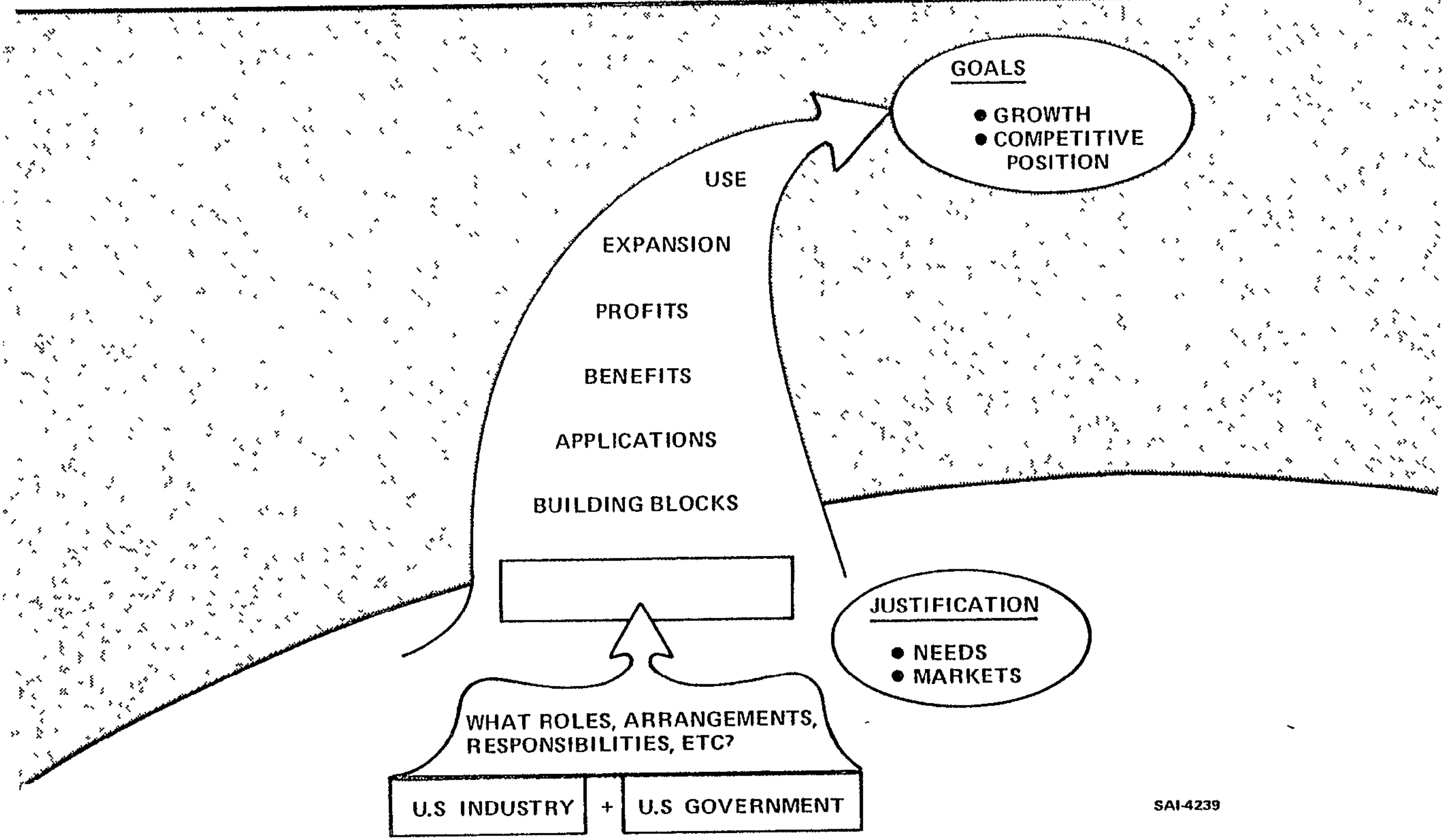
EVOLUTION OF UNITED STATES SI ACTIVITIES

As pointed out on the previous chart, SI holds the promise for economic growth of both the private and public sector. As with the companies and nations of the world referred to on an earlier chart, competitive position is necessary to maximize potential income and growth in the international marketplace. The needs and markets to be satisfied by SI initiatives exist and will grow. The various industrial activities necessary to satisfy these needs and markets will evolve or stagnate in the United States based on the quality and timeliness of the steps shown here leading to the expanded use of space. Fundamental to the realization of goals is the first step. arriving at a proper set of the industry and government roles and responsibilities.

DOMESTIC IMPACTS/ISSUES

SPACE INDUSTRIALIZATION
SCIENCE APPLICATIONS, INC

EVOLUTION OF UNITED STATES SI ACTIVITIES



SAI-4239

SAMPLES OF INDUSTRY POINT OF VIEW

Samples of points of view for three generic industries were gathered through direct contact, literature survey, attendance at special technical meetings and through surveys and studies conducted by others. The data synthesized from these sources were screened specifically for perceptions of where space industrialization stands today; what ideas were prevalent on industry/government roles and responsibilities; and what particular recommendations were offered.

DOMESTIC IMPACTS/ISSUES

SAMPLES OF INDUSTRY POINT-OF-VIEW

PERSONAL

- COMMUNICATIONS
  - 2 CONTACTS
- PRODUCTS
  - 9 CONTACTS (NON-AEROSPACE)
- ENERGY (AND INVESTORS)
  - 4 CONTACTS (NON-AEROSPACE)

INDIRECT

- LITERATURE
- TECHNICAL MEETINGS
- THIRD PARTY

EVALUATED FOR

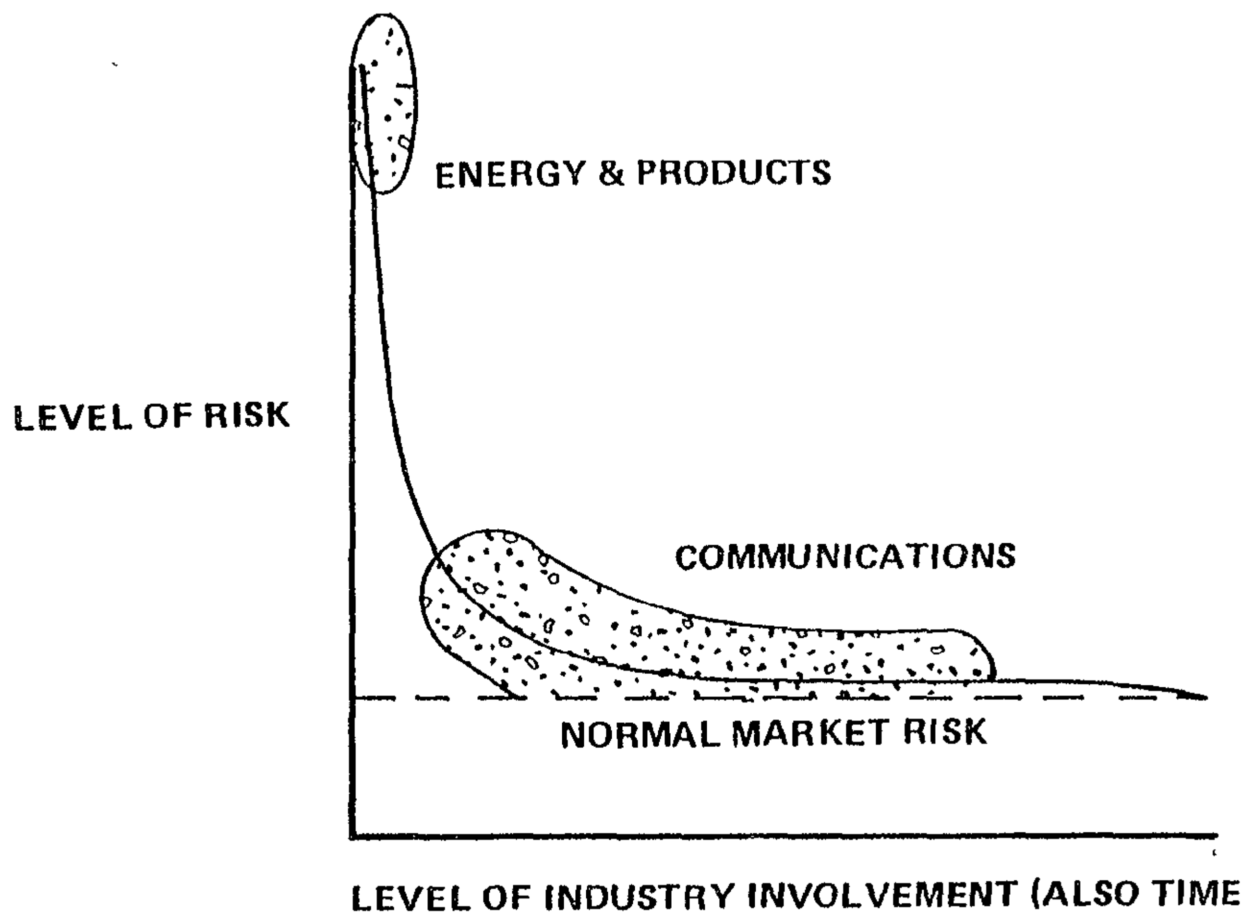
- PERCEPTION
- IDEAS ON ROLES & RESPONSIBILITIES
- RECOMMENDATIONS

SAI-4202

INDUSTRY PERCEPTIONS

The essence of industries perceptions on the status of SI today is summarized in this simplistic qualitative chart. This can also be considered something of a prediction on what will happen given risk reduction initiatives. There is no general lack of faith in the future of space industrialization in any area, only a perception that the economic risks of involvement are very high relative to normal market risks except in the more mature communications industries. As the risks come down with new knowledge, demonstration programs, government initiatives, etc. (marked by the passage of a block of time) it is anticipated by all contacted that the level of industry involvement will increase substantially.

INDUSTRY PERCEPTIONS



SAI-4256

INDUSTRY VIEWS ON ROLES AND RESPONSIBILITIES

The specifics of appropriate roles and responsibilities which could be adopted by industry and government vary broadly according to the industry and the individual. It is possible, however, at the rather gross segregation level presented here to assemble a set of consensus opinions. As might be anticipated the communications industry is sufficiently mature that the Product Development and Pilot Operations areas require consideration of specific proposals to obtain a particular opinion. The large geo platform concept was one initiative that generally fell in the joint venture category for example. A new version of an existing satellite system was considered to be an appropriate industry activity. Particular attention is drawn to the consensus or CEP blocks.

The information presented here is considered as a stage setting providing general guidelines for development of specific arrangements on a case by case basis. Early general agreement to these guidelines by government would encourage enhanced industry involvement in space industrialization.

INDUSTRY VIEWS ON ROLES & RESPONSIBILIITES

INDUSTRY IDEAS ON ROLES & RESPONSIBILITEIS

C – COMMUNICATIONS
E – ENERGY
P – PRODUCTS

	GOVERNMENT ACTIVITY	INDUSTRY ACTIVITY	JOINT VENTURE	GOVERNMENT REGULATION
BASIC RESEARCH	C E P			
APPLIED RESEARCH	E P		C	
PRODUCT DEVELOPMENT	E	C*	C* P	
PILOT OPERATIONS	E	C*	C* P	
PRODUCTION OPERATIONS		C E P		C E
TRANSPORT DEVELOPMENT	C E P			
TRANSPORT OPERATIONS		C E P		C E P

SAI-4242

*DEPENDS ON SPECIFICS

INDUSTRY RECOMMENDATIONS - COMMUNICATIONS

The recommendations reflected here were derived from discussions with individuals working with companies presently in the satellite communications business. They address the three basic issues of how to: promote the use of space on an ever increasing scale; head off a potentially limiting factor in the possible growth and competitiveness of U.S. industry, and enhance both competitiveness and future balance of trade for the United States.

INDUSTRY RECOMMENDATIONS

COMMUNICATIONS

- SUPPORT SPACE BASED COMPETITION TO GROUND CAPABILITIES
- PROMOTE INTERNATIONAL PLANNING ON THE USE OF GEOSYNC BASED ON GOV/INDUSTRY INTEGRATED PLANNING
- STIMULATE LAGGING SUPPORT (SUBSYSTEM) TECHNOLOGIES IN U.S. TO MAINTAIN COMPETITIVE POSITION.

SAI 4245

INDUSTRY RECOMMENDATIONS - PRODUCTS

These recommendations were derived from discussions with industry people in non-aerospace product areas. Enhanced involvement through communications and meaningful dialog is considered desirable and worth considerable effort on both the industry and government side. A better understanding of the potential for space products, implementation of risk reduction arrangements and product relevancy of government sponsored research are viewed as the strongest pulls to increased industry involvement. The long term growth of the space products industry to its apparent potential will depend on one development more than any other, however. The cost of bulk raw material launch to LEO must come down to a few dollars per pound (<$50/LB).

INDUSTRY RECOMMENDATIONS

PRODUCTS

- ESTABLISH BETTER BROAD COMMUNICATIONS WITH DOMESTIC INDUSTRY.
- INCORPORATE MEANS FOR RISK REDUCTION ARRANGEMENTS TO BE MADE.
- REDUCE TRANSPORTATION COSTS BY 10 TO 100 TIMES BELOW SHUTTLE PROJECTIONS
- MAKE RESEARCH RELEVANT TO POTENTIAL PRODUCTS.

SAI-4247

INDUSTRY RECOMMENDATIONS - ENERGY

Two research and development managers for power companies and two investors from life insurance firms (large investors in power) provided insight into views and recommendations regarding SPS. Briefings and data on SPS and SI in general had been previously provided.

Perhaps the two most significant comments are the first and last shown here. The first is a direct admonition to sell the benefits, not the program. The power companies never sold electricity by showing smokestacks, generators, dams and power lines. SPS should be presented to power companies on the basis of generation and distribution benefits to them and sold to the public as an investment in clean, cheap electrical power.

The last point reflects the observation by these reviewers that the demands for power in space in the eighties and nineties will provide a strong forcing function for an SPS prototype size program. A technology and development program should thus be possible which maximizes benefit to both SPS and future information systems.

DOMESTIC IMPACTS/ISSUES

SPACE INDUSTRIALIZATION
SCIENCE APPLICATIONS, INC

INDUSTRY RECOMMENDATIONS

ENERGY

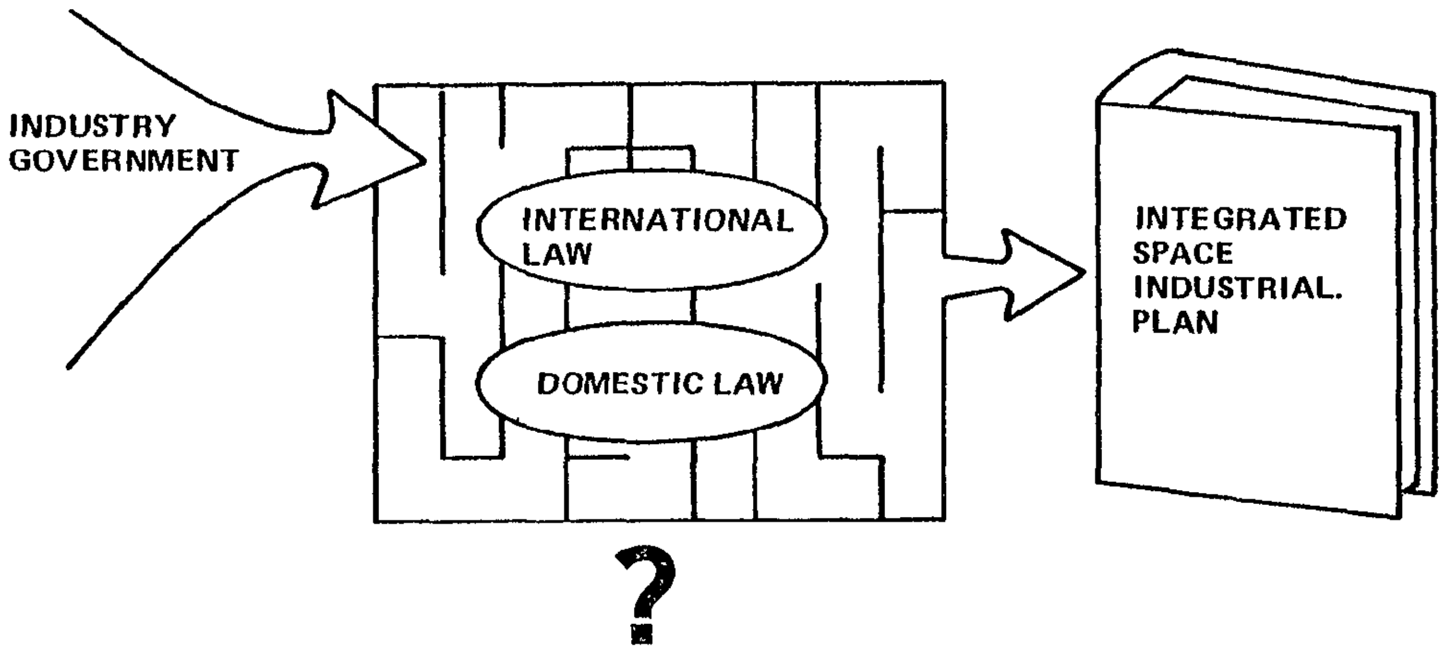
- TREAT SPS LIKE A POWER PROGRAM, NOT A SPACE PROGRAM
- PLAN TOWARD DEMONSTRATION OF ACCEPTABLE RISK LEVELS FOR INVESTORS.
- PUT STRONG EMPHASIS ON JOB IMPACTS AND OTHER USES FOR HYDROCARBON RESOURCES.
- FACE UP TO ENVIRONMENTAL ISSUES EARLY
- GO FOR STRONG INFORMATION SYSTEM SYNERGY.

SAI-4248

THE MAZE OF SPACE LAW

As shown by the previous charts and discussions, both industry and government are interested and motivated to attempt establishment of working relationships to promote SI. The consideration of possible legal difficulties then becomes of substantial interest, particularly if some initiative is currently blocked by international or national law. To explore this three experts in various aspects of space law were polled on an informal basis for opinions. A cursory review of the reams of literature on the subject was also conducted to obtain the flavor of opinions and counter-opinions being expressed in print.

THE MAZE OF SPACE LAW



HOW TORTUOUS THE PATH? ARE THERE BLOCKS?

ASSESSED BY:

✓ EXPERT REVIEW (INFORMAL TO SAI)

- DELBERT D. SMITH
- KATHERIN D. HALLGARTEN
- ART DULA

✓ LITERATURE REVIEW

SAI-4249

GENERAL CONSENSUS - INTERNATIONAL

The literature review supported the opinion that much discussion on international law and space is in progress but that no seriously limiting universal agreements have been made. However, a number of equatorial and/or developing nations have expressed their determination to play a larger role in controlling space industrialization by international agreement. This is exemplified by the current attempts to increase the number of such countries represented on the U. N. Committee on the Peaceful Uses of Outer Space to the point where they would have the majority vote.

The last point presents that action needed to quiet an often expressed fear that some potentially desirable long range goals (such as use of lunar material) may be precluded or seriously hampered by improperly coordinated treaty agreements.

LEGAL CONSIDERATIONS

GENERAL CONSENSUS – INTERNATIONAL

- MUCH INTERPRETATION, NEGOTIATION AND RHETORIC IN PROGRESS
- NO SERIOUSLY LIMITING TREATIES OR INTERNATIONAL LAW IN EFFECT.
- PRESSURE IN U.N. TO ADOPT MOTIONS LIMITING SI ACTIVITIES WILL PROBABLY INCREASE.
- INTEGRATED TECHNICAL, ECONOMIC AND LEGAL PLANNING NECESSARY TO AVOID FUTURE PROBLEMS.

SAI-4264

GENERAL CONSENSUS - DOMESTIC

Policies and rules (often based on interpretation of law) seem to have the highest potential for domestic impediment of space industry initiatives. Policies related to control of systems and data (such as Landsat and shuttle/spacelab for example) have received substantial attention and some trends as reflected by the quote here are apparent. Some laws and rules, imposed due to other national considerations, may inhibit the bringing together of sufficient capital and capability to address the more aggressive SI programs. The impact of such prior enactments will have to be addressed on a case by case basis as circumstances dictate unless general guidelines are established ahead of time. Because of the special factors surrounding potential SI investments, it is considered extremely important by our reviewers that industry viewpoints be factored into any proposed tailoring of laws and policy affecting SI.

LEGAL CONSIDERATIONS

GENERAL CONSENSUS – DOMESTIC

- "THESE. . .CONSIDERATIONS SUGGEST THAT PRIVATE SECTOR PARTICIPATION IN SPACE OPERATIONS IS DESIRABLE. NONETHELESS, A NUMBER OF TRENDS SUGGEST THAT NATIONAL. . .POLICY MAY BE MOVING AWAY FROM PROMOTION OF FULL-SCALE COMMERCIAL INVOLVEMENT."
  –D. D. SMITH
  (With Amens)

- ANTI-TRUST LAW AND SEC RULES APPEAR TO LIMIT "DISTRIBUTION OF RISK".

- CONSIDERATION OF INDUSTRIES VIEWPOINT IS IMPERATIVE IN TAILORING LAW AND POLICY TO PROMOTE SI.

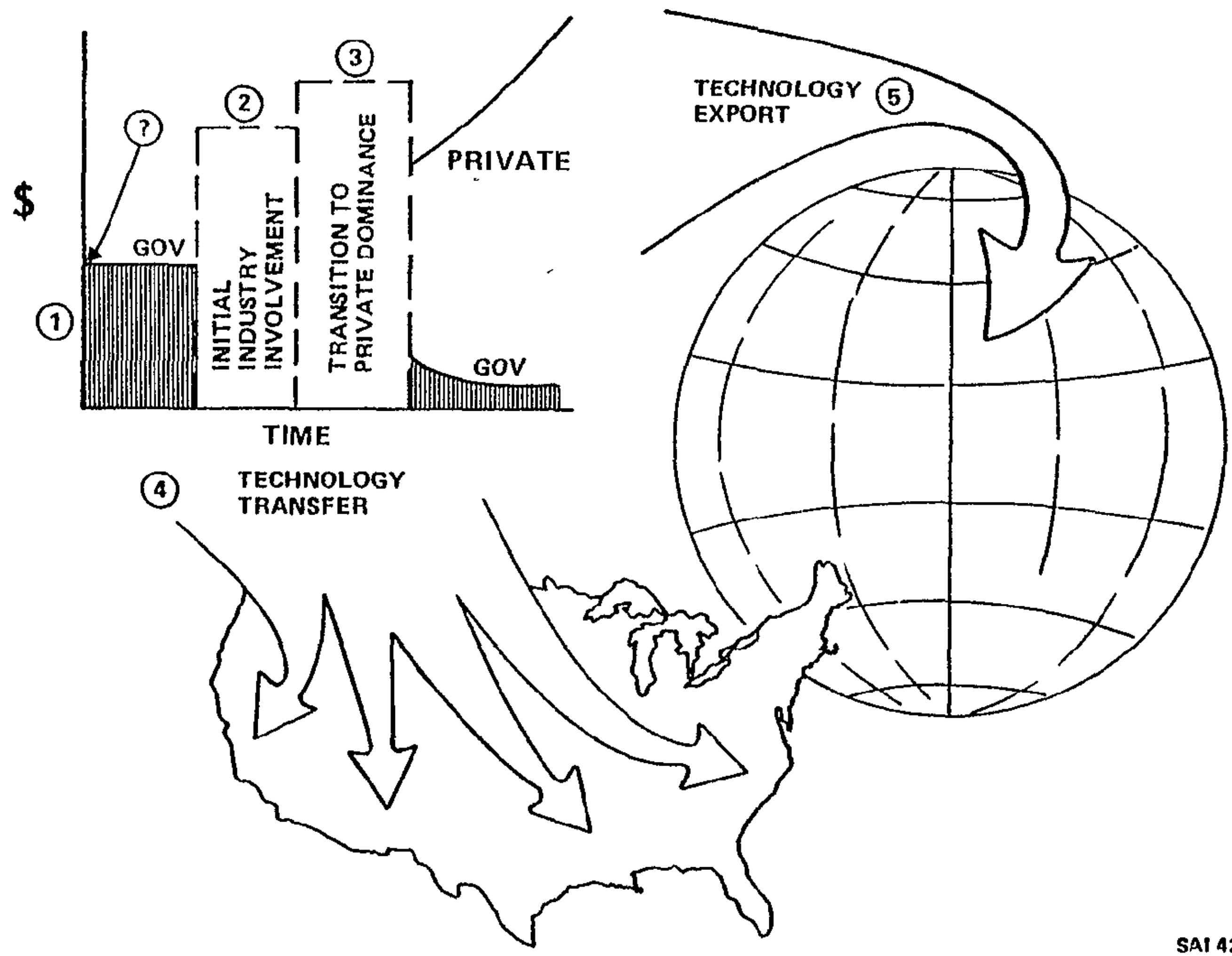
SAI-4258

FIVE SIGNIFICANT CONSIDERATIONS

Illustrated here are the five most significant institutional implications given specific attention in this study out of the dozens which were postulated. They are numbered here in reference to the next chart which discusses the implications and required actions.

Space industry activities in existence today have already addressed the five items to whatever degree was necessary to achieve implementation. Some proposed industry activities are in transitional phases and some have been stagnated awaiting institutional and policy changes. In the environment of applications oriented space endeavors in the US and the world it would appear that space industrialization will represent an increasing fraction of total non-military space expenditures, probably 80 to 90 percent in the early 1980s. Thus it would seem imperative that the over-arching concepts of space industrialization must be factored into the planning, implementation and exploitation of all new future space capabilities.

FIVE SIGNIFICANT CONSIDERATIONS



SAI 4259

FIVE SIGNIFICANT CONSIDERATIONS

These five items are keyed to the previous chart and the accompanying discussion. The government/industry/academic institutional arrangements necessary to accomplish tasks 1 through 3 and optimize benefit from 4 and 5 must be designed in a fashion responsive to the needs of individual SI initiatives. The first steps can be taken, however, by establishing a planning office responsible for the integration of space industrialization elements into all national space activities and plans. This office would supply the data for decisions on items 4 and 5 and formulate plans and focus for accomplishing items 2 and 3.

INSTITUTIONAL IMPLICATIONS

FIVE SIGNIFICANT CONSIDERATIONS

1. SPACE INDUSTRIALIZATION MUST BECOME AN INTEGRAL PART OF NATIONAL SPACE POLICY PLANNING.
2. INDUSTRIALIZING ORGANIZATIONS AND LEGAL STRUCTURES MUST EVOLVE AND BE ENCOURAGED.
3. MECHANISMS FOR ADVANTAGEOUS TRANSFER OF RESPONSIBILITY NECESSARY.
4. THE APPLICABILITY OF SI TECHNOLOGIES TO MANY PROBLEMS, NEEDS AND MARKETS WILL GO UNNOTICED WITHOUT FOCUSED DIALOG.
5. THE KNOTTY ISSUES OF TODAY IN TECHNOLOGY EXPORT WILL BE FURTHER DRIVEN BY THE INTERNATIONAL/ MULTINATIONAL NATURE OF SI.

SAI-4250

THE KEY QUESTION IN SI

Simply stated, does it appear likely that private industry will significantly increase its involvement in space industrialization even if the institutional requirements can be sorted out in a generally compatible fashion? The bottom line involves the economics of the space operation, especially when compared to terrestrial alternatives.

THE KEY QUESTIONS IN SI

HAVE DISCUSSED

- ✓ NEED FOR
- ✓ PROBLEMS OF
- ✓ IMPLEMENTATION OF

PRIVATE SECTOR IN SI.

KEY QUESTION:

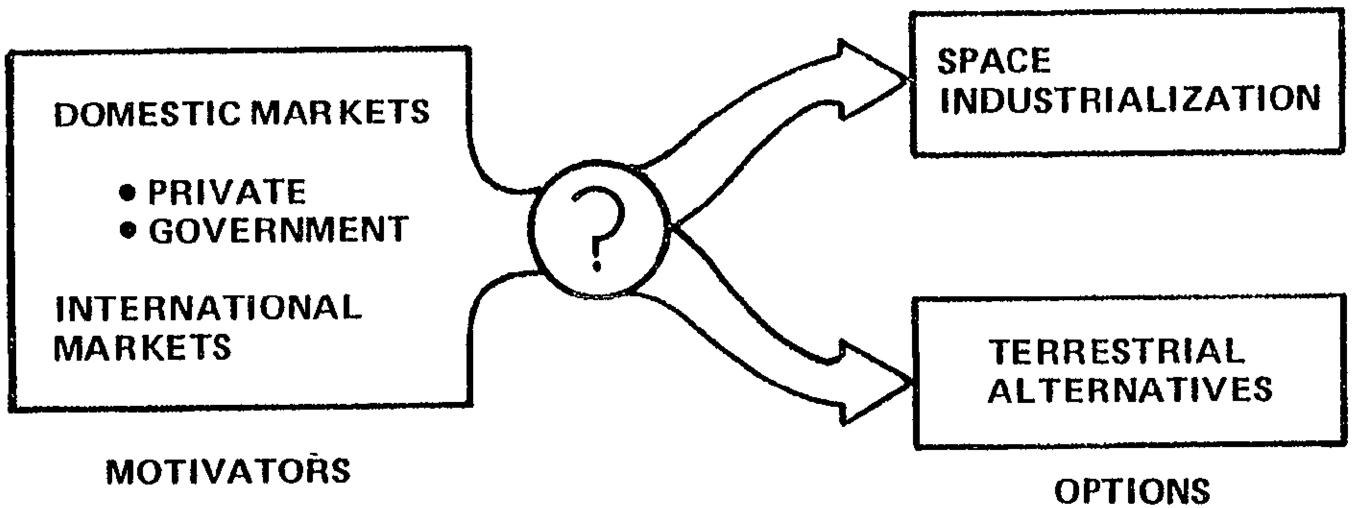
WILL PRIVATE INDUSTRY FURTHER ITS PRESENT INVOLVEMENT SUBSTANTIALLY?

PRIVATE INDUSTRY INVOLVEMENT

As represented here, the markets for industry both domestically and on the international scene provide the motivation for providing a service or product. A decision is then required on which option to pursue to provide that service or product. Recognizing this, considerable effort was expended in both Part 1 and Part 2 of the study to compare SI initiatives to viable terrestrial alternatives.

EXAMPLE ECONOMICS

PRIVATE INDUSTRY INVOLVEMENT



SAI-4240

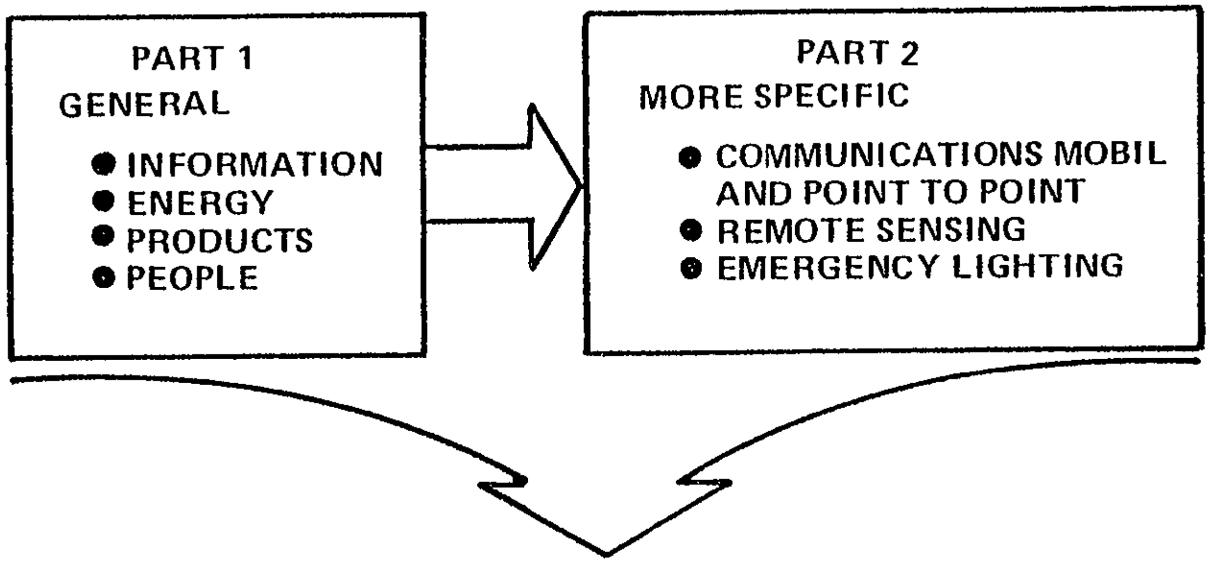
TERRESTRIAL ALTERNATIVES ASSESSMENT

In Part 1 of the study very general qualitative and quantitative comparisons were done, resulting in a few SI initiative deletions. More detailed and specific alternatives were postulated and examined in Part 2. It was found, however, that SI initiatives were not really sold or dismissed by straight-forward economic assessments of capability comparisons. Postulates of what the companies characteristics and vested interests are when such trades are made figure strongly into the selection. In each case examined, circumstances leading both to turn down <u>and</u> implementation decisions could be hypothesized

EXAMPLE ECONOMICS

SPACE INDUSTRIALIZATION
SCIENCE APPLICATIONS, INC

TERRESTRIAL ALTERNATIVES ASSESSMENT



GENERAL CONCLUSIONS

- ALTERNATIVES ALWAYS EXIST.
- AN EXACT, OBJECTIVE ECONOMIC VIABILITY DETERMINATION IS HIGHLY DEPENDENT ON SPECIFICS
- ADVOCACY AND VESTED INTERESTS ARE KEY DETERMINANTS IN SELECTION PROCESS

SAI-4251

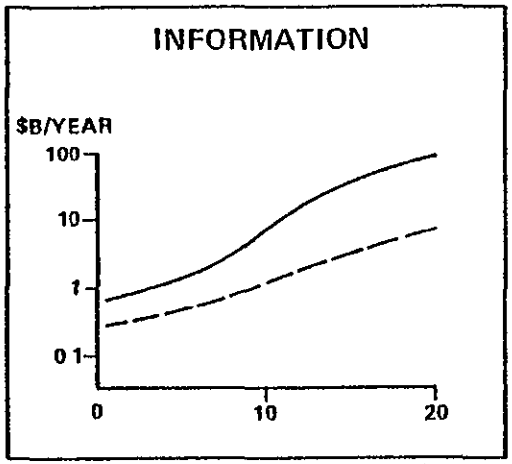
THE GENERIC MARKETS

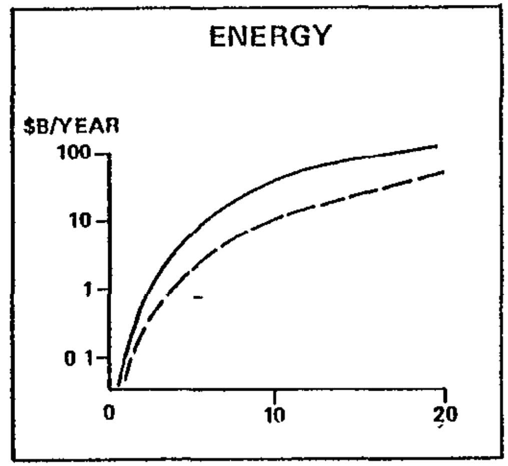
To be generally attractive, a capital intensive new market must hold substantial promise for revenue and net profit. From the analysis in Part 1 of this study (which quantified the elements of the market potentials summarized here) it was concluded that the projected revenues were sufficiently attractive as to spur industry interest in the coming years.

EXAMPLE ECONOMICS

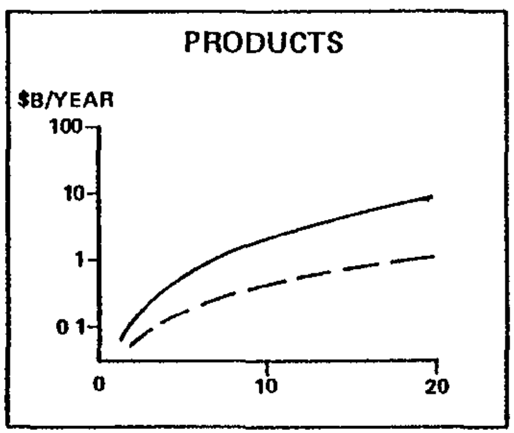
SPACE INDUSTRIALIZATION
SCIENCE APPLICATIONS, INC

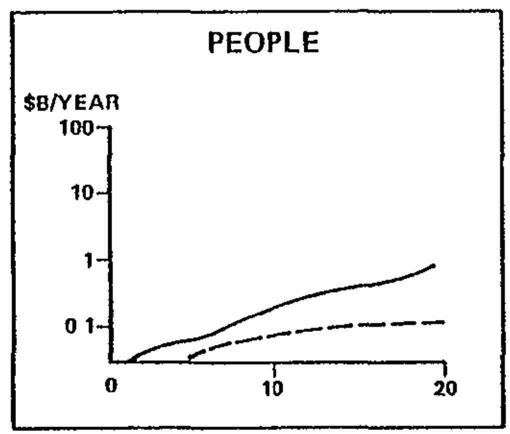
THE GENERIC MARKETS





NOTE· BEST CASE ——— LEAST CASE — — — —





SAI 4254

PART 1 REVENUE ANALYSIS SHOWED THAT THE
GENERIC MARKETS WERE ATTRACTIVE QUANTITATIVELY.

ECONOMICS CONSIDERED

From the market projection data of Part 1 of this study could be selected those initiatives showing the largest individual potential revenues. Thus in Part 2 it was desirable to examine the details of these specific initiatives and determine investment and cash flow requirements to further assess economic viability. As illustrated here, however, the right combinations of detailed knowledge supporting original contribution by the study were available only in the Information Services area. Five services were selected for analysis based on their major contribution to the overall information market potential.

ECONOMIC VIABILITY ASSESSMENT

Comparisons to current communications industries were made to derive average figures for net profit margin and non-hardware operational expenses. Rockwell International, in the companion study to this one, derived hardware costs related to these five initiatives for the first platform. Using market projections from Part 1 of the SAI study we derived a prediction of channels needed and sized the space systems requirements and estimated production and deployment costs as a function of time. With all the required cost data together a string of projected costs and revenues was calculated.

The "Initial Capital" requirement reflects that amount of money required to establish the service and initiate revenue income. "Capital Before Breakeven" reflects the maximum debt incurred (cumulative cash flow) prior to the cash flow break even time when outlay and income balance. "Rate of Project Return" is an investment judgment tool which allows comparison of economic benefit gained relative to other potential investments. A return of 10% would mean that the investor is breaking even relative to a 10% discounted investment. All figures quoted are computed against a positive future scenario assuming needed structures, power and transportation technologies will come to pass as specified in a later chart.

SPACE INDUSTRIALIZATION
SCIENCE APPLICATIONS, INC

ECONOMICS CONSIDERED

PART 2 OBJECTIVE ➧ GENERIC TO SPECIFIC

HOWEVER:

- INFORMATION

  5 Services ≈ 80% Revenues
- ENERGY

  SPS Examined Elsewhere
- PRODUCTS

  Exact Details Imperative
- PEOPLE

  Viability Depends on Above Three

THEREFORE ASSESSED:

✓ POCKET TELEPHONE

✓ ADVANCED TV

✓ NAT'L INFO SERV

✓ TELECONF

✓ ELECTRONIC MAIL

SAI-4266

63

ECONOMIC VIABILITY ASSESSMENT

ASSUMPTIONS

- 15% NET PROFIT MARGIN
- HARDWARE COSTS FROM RI
- DOE SHARES DEVELOPMENT COST (50%)
- NUMBER OF CHANNELS AND SYSTEM SIZE LINEAR
- INVESTMENT DISCOUNTED AT 10%
- COMPANY INFRASTRUCTURE EXISTS PRIOR TO INITIATION
- ANSWERS ARE SCENARIO DEPENDENT

SERVICE	INITIAL CAPITAL	CAPITAL BEFORE BREAKEVEN	RATE OF PROJECT RETURN
PERSONAL COMM	$420M	$420M	14%
ADVANCED TV	$200M	$200M	17%
NATIONAL INFO	$420M	$620 – $640M	17%
TELECONF	$254M	$2126M	11%
ELECTRONIC MAIL	$4,260M*	—*	—

*STRONG FUNCTION OF ASSUMPTIONS. BREAKEVEN NEVER ACHIEVED FOR POST OFFICE TO POST OFFICE SYSTEM ASSUMED HERE.

SAI-4265

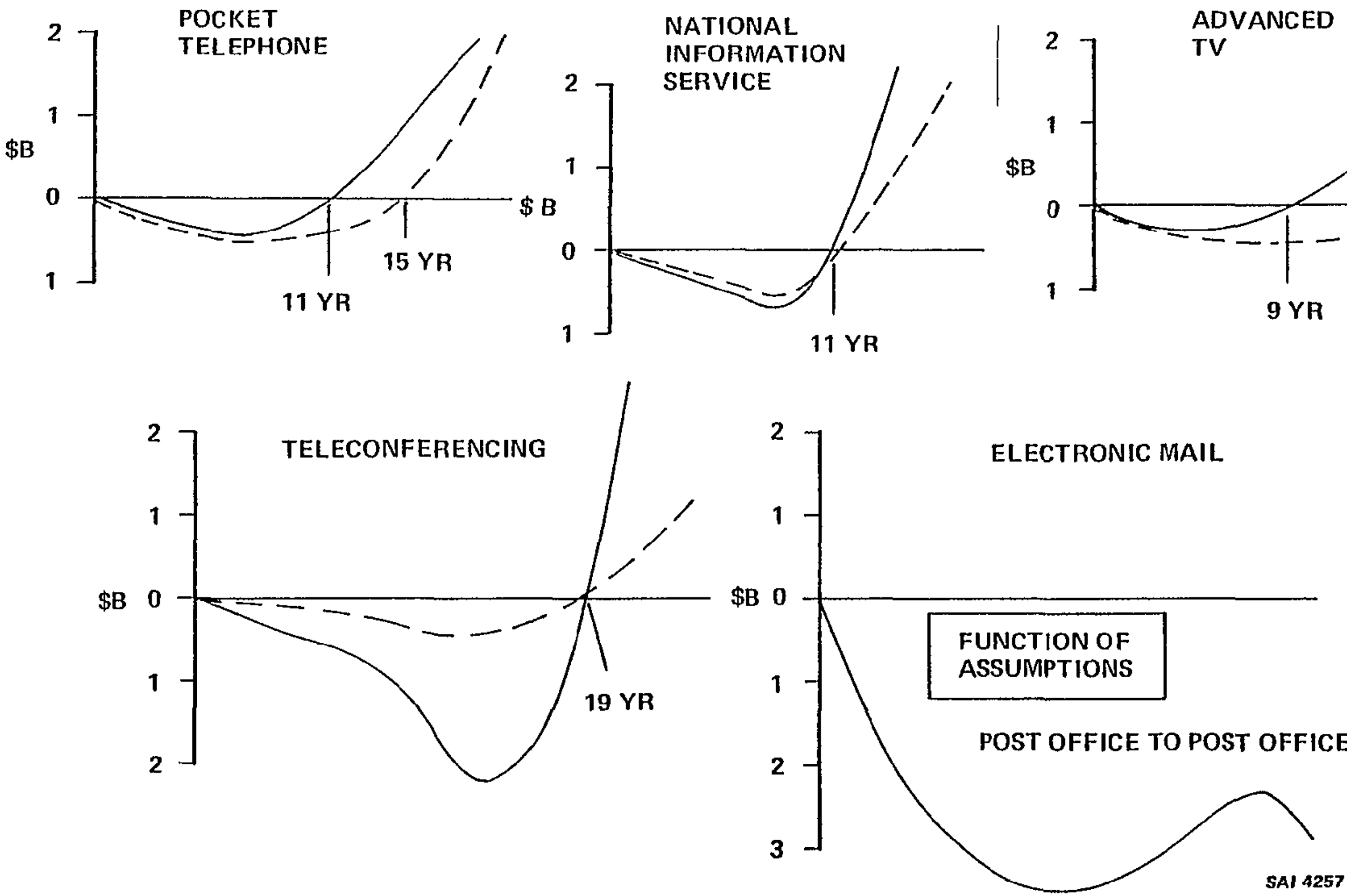
CUMULATIVE CASH FLOW REQUIREMENTS

The string of costs and revenues referred to in the previous chart are presented graphically with the number of years to achieve breakeven specified. It was not possible in this study to optimize the R & D, investment, debt, market penetration rates, technical synergy and other factors affecting these curves. Also, a more aggressive market scenario could easily lead to economies of scale not realized here. Thus we feel the time to breakeven is generally conservative although not unattractive here considering the tens of billions of dollars potential annual revenue.

The Electronic Mail initiative examined here was different from that delineated in Part 1 of the study which assumed home to home delivery. The Post Office to Post Office system postulated by RI appears to be economically infeasible at current first class letter rates. A careful analysis of the effect of rates and house to house delivery should be made before final judgment on the concept.

EXAMPLE ECONOMICS

CUMULATIVE CASH FLOW REQUIREMENTS



VIABILITY ASSESSMENT RESULTS

Although Electronic Mail in the form assumed here appears unattractive, the remaining four SI opportunities appear very attractive. An examination of recent literature related to satellite communications systems indicates that rudimentary forms of these initiatives are already in the planning stages. But how large will these industries grow and what markets will they command? The answer lies in what R&D commitments are made in the next five to ten years that provide the technological basis for aggressive industry programs in the eighties and nineties

EXAMPLE ECONOMICS

VIABILITY ASSESSMENT RESULTS

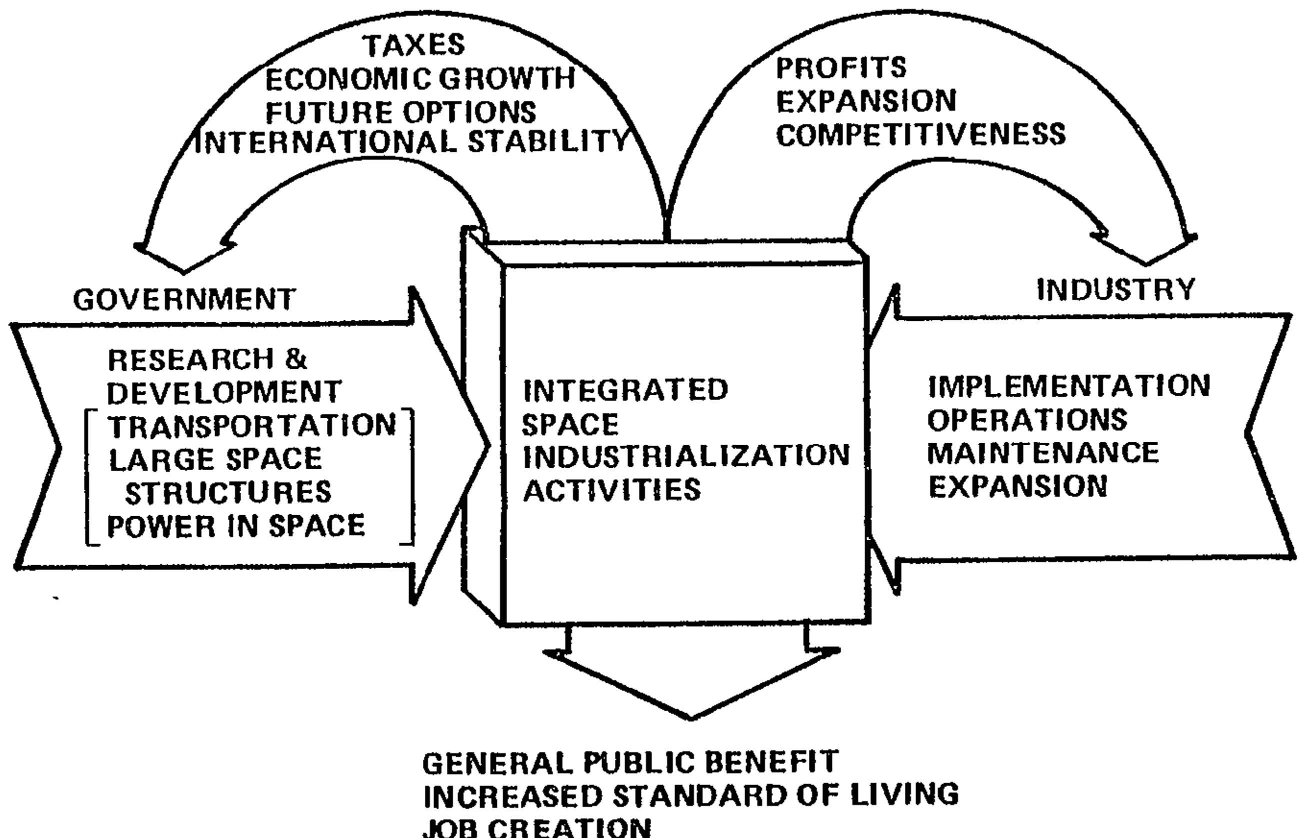
- FOUR (4) OF FIVE (5) OPPORTUNITIES EXAMINED IN DETAIL APPEAR VERY ATTRACTIVE (WITHIN ASSUMPTIONS)
- COMPLEXITY INVERSION, LARGE SPACE SYSTEMS AND TRANSPORTATION ARE KEY TECHNOLOGIES.
- REALIZATION OF THE 10 TO 40 BILLION DOLLAR MARKET POTENTIAL OF THESE OPPORTUNITIES WILL REQUIRE VERY LARGE GEO PLATFORMS IN THE 90s WITH ECONOMICAL OPERATIONS.

SAI 4263

PART 2 RESULTS OVERVIEW

This chart summarizes the How and Why of Space Industrialization as examined in Part 2 of this study. The roles and related activities of government and industry feed the integrated SI activities that represents the summation of all future private and public SI programs. The motivators for such input and sponsorship are shown as a feedback loop. Three encompassing benefits to the public at large are shown as the integrated "value generation" of space industrialization. Net value generation is possible because a new and virtually inexhaustable resource, loosely called "space", is being utilized.

PART 2 – RESULTS OVERVIEW



SAI-4238

GENERAL RECOMMENDATION

Space Industrialization is, as Ehricke termed it, the overarching concept capable of encompassing and coordinating future applications of space in the most beneficial manner. The individual initiatives in the industrial activities identified in this study should not be pursued as autonomous projects unto themselves. This study has shown that the concepts of space industrialization are viable; that synergistic relationships are possible and desirable; and that industry/government cooperative planning and implementation are desirable and feasible. For various reasons industry will be loath to establish long term goals that carry near term investment commitments, thus government must lead in planning The assumption of authority and responsibility by industry at an appropriate point in the life cycle of an initiative will require operating characteristics that should be established as part of the design and development process. In this area industry must lead.

GENERAL RECOMMENDATIONS

- ESTABLISH GOALS FOR SI IN CONCERT WITH VARIOUS GOVERNMENT AGENCIES AND PRIVATE INDUSTRY. MOST WILL BE IN THE EIGHTIES BUT SOME MUST BE IDENTIFIED FOR THE NINTIES AND BEYOND TO OBTAIN OVERALL GUIDANCE.

- PLAN FOR THE INVOLVEMENT OF, AND TRANSITION TO, PRIVATE INDUSTRY AT THE EARLIEST OPPORTUNITY OF ALL SI INITIATIVES WITH PUBLIC SERVICES BECOMING A CUSTOMER. CONSENSUS OPINION IS THAT THIS WILL MAXIMIZE PUBLIC BENEFIT.

SAI-4244

SPECIFIC RECOMMENDATIONS

The recommendations most strongly expressed by our industry contacts were presented earlier. Although the level of specificity varies, they are all expressions of a positive nature intended to enhance the near and long term growth of space industrialization.

One recurring message has appeared throughout this study when the origins and reasons for success of various projects was examined. It is that three elements were recurrent. They were.

1. The concept was technically sound.
2. Its evolution was well coordinated and the concepts and developments involved widely displayed.
3. Strong advocacy was provided by a small group of well informed, hard working people.

In recent years a fourth element has often been required: application to a need, although there are notable exceptions in recent years in the scientific community of course. It is these general observations that prompt our recommendation that a special Office for Space Industrialization Planning, Integration and Implementation be established to focus SI efforts.

SPECIFIC RECOMMENDATIONS

- INCORPORATE IN PLANNING AND ACT ON ALL PRIVATE INDUSTRY RECOMMENDATIONS DISCUSSED EARLIER.
- ESTABLISH AN OFFICE FOR SI PLANNING, INTEGRATION AND IMPLEMENTATION REPORTING TO THE NASA ADMINISTRATOR.
- CONDUCT THE SERIES OF STUDIES RECOMMENDED IN THE SAI FINAL REPORT. THE SUBJECTS AND SEQUENCES ARE DESIGNED TO CONVERGE ON ANSWERS TO QUESTIONS DELINEATED HERE.

SAI-4246

SI STRUCTURES, POWER AND TRANSPORT REQUIREMENTS

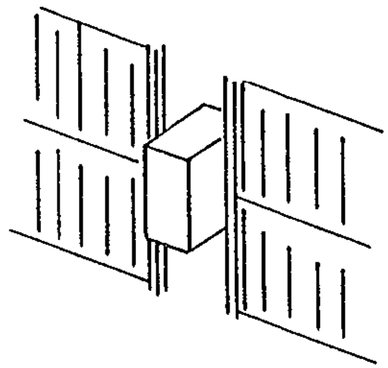
This study has shown that commercially viable industries in Information Services, Energy and Products can be realized given the tools illustrated here for private enterprise to work with. Our analysis has also shown that public investment in these capabilities in the eighties will be paid back manyfold in the nineties and beyond. All indications are that Space Industrialization is the catalyst required to swing the United States and the world upward toward the next plateau of human achievement. This will be achievement *in toto*, not just in space or on the Earth but throughout the sphere of human endeavor. We believe that implementation of our recommendations and aggressive pursuit of the overarching concept of Space Industrialization will be concrete steps toward realization of these achievements.

CONCLUSIONS

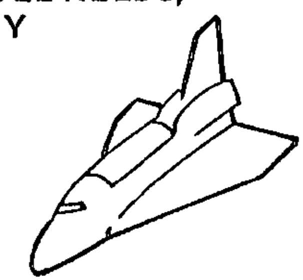
SPACE INDUSTRIALIZATION
SCIENCE APPLICATIONS, INC

SI STRUCTURES, POWER & TRANSPORT REQUIREMENTS

1980–1985

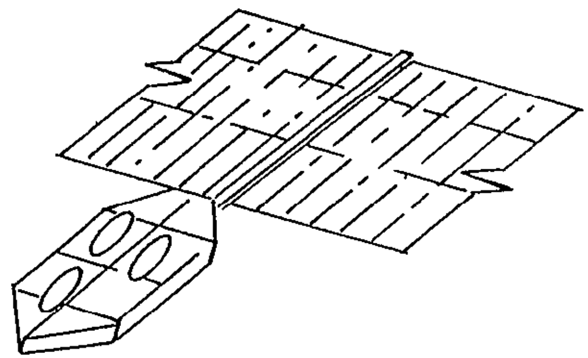


25 75KW
JUSTIFIED BY SPACE PROCESSING, SHUTTLE NEEDS, COMM. TECHNOLOGY

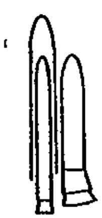


SHUTTLE
$250 $350/LB

1985–1990



200 -- 500 KW
JUSTIFIED BY GEO PLATFORM, SPS

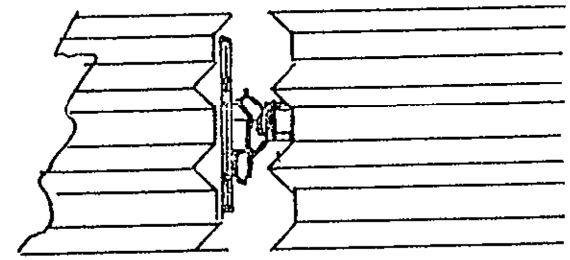


OTV

HLLV -1

$100 $150/ LB LEO
JUSTIFIED BY PRODUCTS, INFORMATION AND ENERGY

1990–1995



1,000 10,000 KW
JUSTIFIED BY NEEDS OF LARGE SCALE COMM. INITIATIVES, SPS

SSTO

SEPS

HLL'

LOW COST SYSTEMS
$20 - $50/LB LEO
JUSTIFIED BY PRODUCTS, INFO. AND ENERGY

SAI-42

APPENDIX C

SPACE INDUSTRY OPPORTUNITIES

INFORMATION

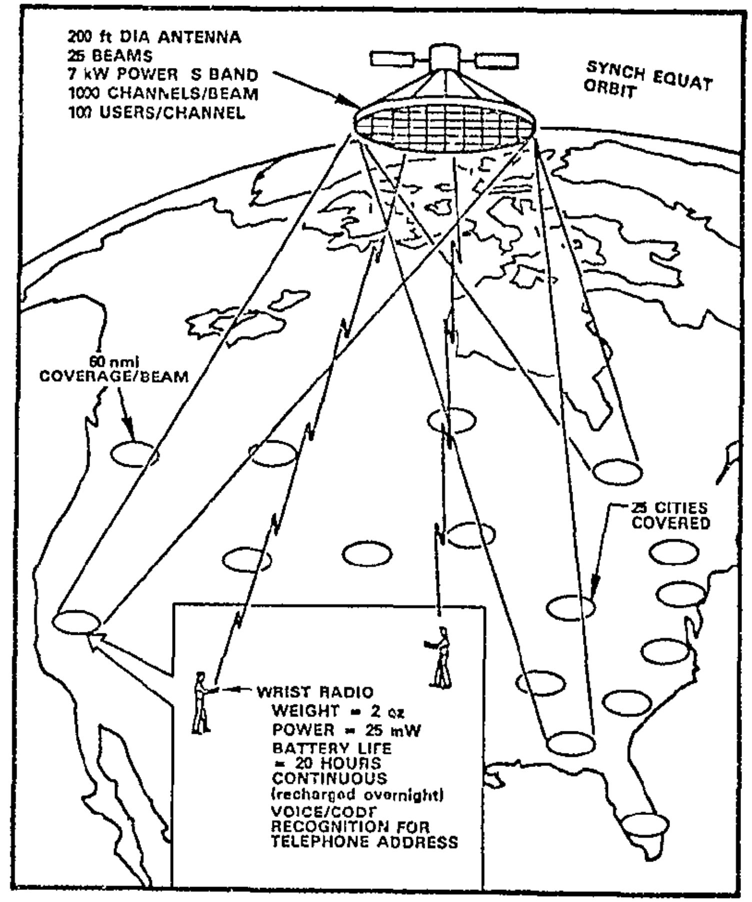
E-0935R3

PERSONAL COMMUNICATIONS WRIST RADIO (CC-9)

- **PURPOSE**
  To allow citizens to communicate through exchanges by voice, from anywhere.

- **RATIONALE**
  Mobile telephones are desirable, but should be wrist worn Uses include emergency, recreation, business, rescue, etc

- **CONCEPT DESCRIPTION**
  Multichannel switching satellite and wrist transmitter-receivers connect people anywhere to each other directly or to telephone networks Analog or vocoded voice used



- **CHARACTERISTICS**

• WEIGHT	16,000 lb
• SIZE	200 ft dia antenna
• RAW POWER	21 kW
• ORBIT	Synch. Equat.
• CONSTELLATION SIZE	1
• RISK CATEGORY	1 (Low)
• TIME FRAME	1990
• IOC COST (SPACE ONLY)	300M.

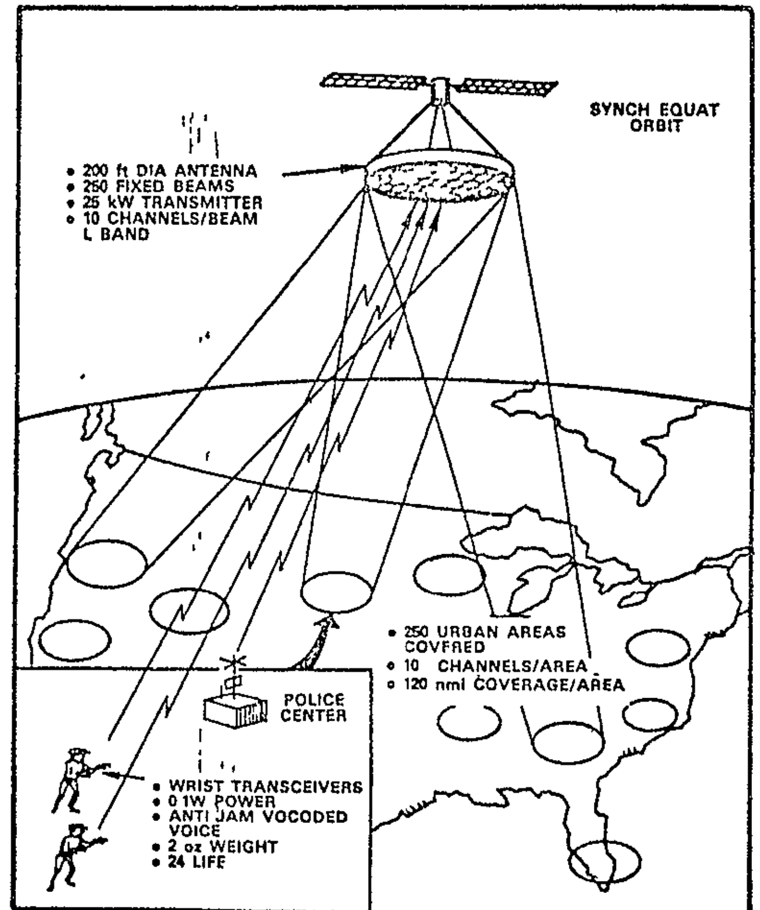
- **PERFORMANCE**
  25,000 simultaneous voice channels, each shared by up to 100 users: 2.5 million people communicate by normal voice.

- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and large/tandem tug or SEPS
• ON-ORBIT OPERATIONS	Automated or manual servicing unit; assembly on orbit
• SUBSYSTEMS	Attitude control; antenna; processor; repeater
• TECHNOLOGY	Large multibeam antenna, multi-channel repeater, LSI processor, multiple-access techniques
• OTHER	Wrist transceiver, LSI technology

E-0930R2

URBAN/POLICE WRIST RADIO (CC-2)



- **PURPOSE**
  To give real-time, secure, anti-jam, high coverage, wide area personal communications to each policeman.
- **RATIONALE**
  Portable/personal sets needed to increase police mobility/safety. Jamming/eavesdropping will become routine
- **CONCEPT DESCRIPTION**
  Wrist 2-way transceiver and channelized Comsat give instant 2-way communications to patrolmen. Multibeam antenna, anti-jam processing, and pseudo-random coding make jamming difficult.
- **CHARACTERISTICS**

• WEIGHT	18,000 lb
• SIZE	200-ft dia antenna
• RAW POWER	75 kW
• ORBIT	Synch Equat.
• CONSTELLATION SIZE	1
• RISK CATEGORY	I (Low)
• TIME FRAME	1990
• IOC COST (Space only)	390 M

- **PERFORMANCE**
  10 Channels/city area, 250 areas simultaneously. Resists 1 kW uplink jammer and 40 kW downlink jammer two miles distant.
- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and large tug or SEPS
• ON-ORBIT OPERATIONS	Automated or manual servicing unit; assembly on orbit
• SUBSYSTEMS	Attitude control; antenna; processor
• TECHNOLOGY	Large multibeam antenna; multi-channel transponder; LSI processor; multi-access techniques
• OTHER	Wrist transceiver, LSI technology

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Education

PRODUCT/SERVICE: Transmission and/or Rebroadcast

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Use space as a repeater or broadcast station for educational TV to increase possible audience coverage and lower cost. Using bigger antennas, smaller receivers are possible and thus much lower user cost. Should piggyback on public communications platform. Advantage of space is wide audience and numerous parallel channels available.

1) U. S. Secondary
2) Third World
3) Adult U. S.
4) Adult Third World

CHARACTERISTICS:

TECHNOLOGY: Large Antenna

IOC: Near Mid-Term

SITE: GSO

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH: Moderate

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

3-D HOLOGRAPHIC TELECONFERENCING (CC-11)

- **PURPOSE**

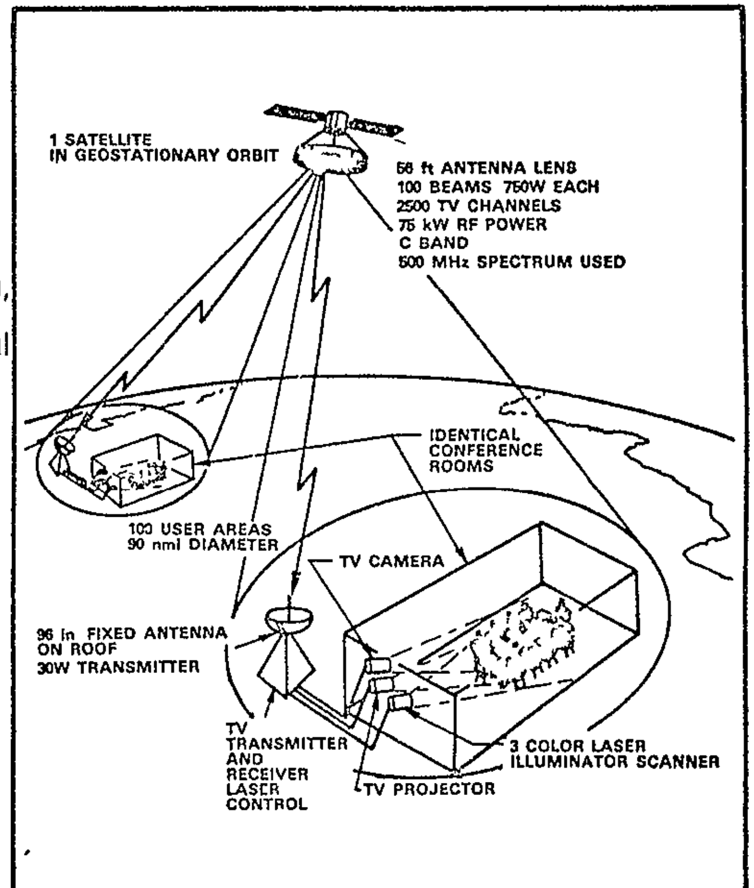
  To greatly reduce the need to travel for most government or private industry business conferences without significant loss in ability to transact business.

- **RATIONALE**

  Travel for conferences is costly, time consuming, and inefficient.

- **CONCEPT DESCRIPTION**

  Identical conference rooms are fitted with a T. V. camera, T. V projector, and laser illuminator and stereo sound system. Resulting holograms produce three-dimensional images that can walk, talk, and present data



- **CHARACTERISTICS**

• WEIGHT	15,000 lb
• SIZE	56-ft antenna
• RAW POWER	220 kW
• ORBIT	Geostationary
• CONSTELLATION SIZE	1
• RISK CATEGORY	III (Medium)
• TIME FRAME	1990
• IOC COST (Space only)	500 M

- **PERFORMANCE**

  1,250 identical conference rooms in 100 urban areas interconnected simultaneously with 3-D color holographic images and stereo sound.

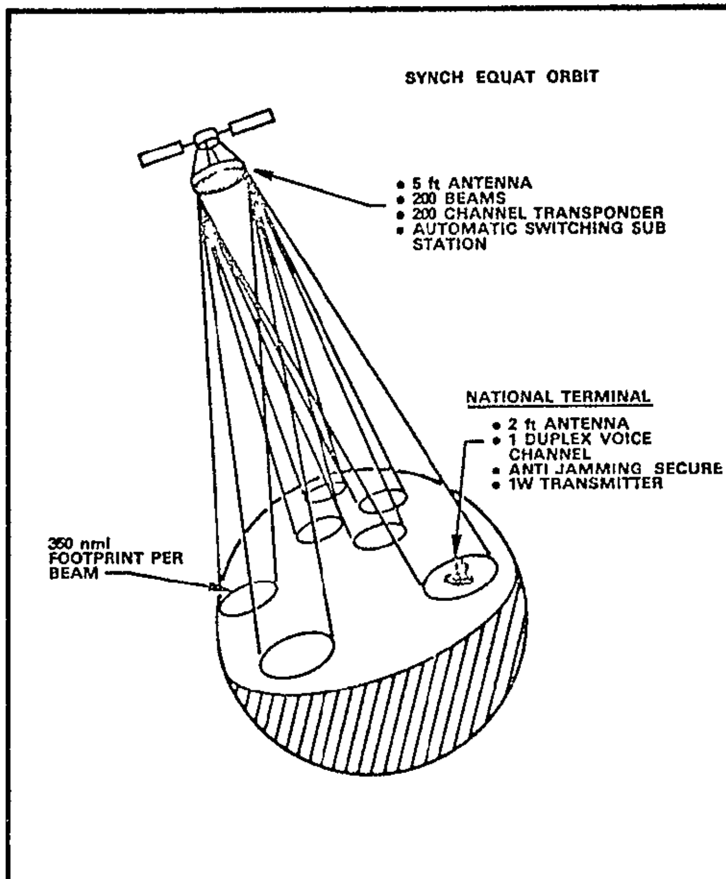
- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle, large/tandem tug or SEPS
• ON-ORBIT OPERATIONS	Automated or manual assembly and servicing
• SUBSYSTEMS	Large multibeam antennas, processors, high power transmitter
• TECHNOLOGY	High power transmitters - LSI processors, prime power source
• OTHER	User equipment, holographic quality, image motion compensation

ORIGINAL PAGE IS OF POOR QUALITY

4

DIPLOMATIC/U.N. HOTLINES (CC-10)



• PURPOSE

To provide rapid, reliable, secure communications between heads of state (or embassies).

• RATIONALE

Good, rapid communications needed to reduce dangers of escalation in international situations.

• CONCEPT DESCRIPTION

Multibeam antenna Comsat crosslinks any or all terminals, one per country Satellite processing is autonomous and not subject to capture.

• CHARACTERISTICS

• WEIGHT	3000 lb
• SIZE	5 x 20 ft
• RAW POWER	1 kW
• ORBIT	Synch. Equat.
• CONSTELLATION SIZE	3
• RISK CATEGORY	1 (Low)
• TIME FRAME	1985
• IOC COST (Space only)	330 M

• PERFORMANCE

One full duplex voice channel per country, secure, 200 countries accommodated. Automatic switching in satellite; or multiple access user-controlled.

• BUILDING BLOCK REQUIREMENTS

• TRANSPORTATION	Shuttle and IUS/tug
• ON-ORBIT OPERATIONS	Automated or manual servicing unit
• SUBSYSTEMS	Attitude control; antenna; processor and switch
• TECHNOLOGY	Multibeam antenna; multi-channel transponder; LSI processor and automatic switch; multiple-access techniques
• OTHER	None

5

NATIONAL INFORMATION SERVICES (CC-8)

- **PURPOSE**

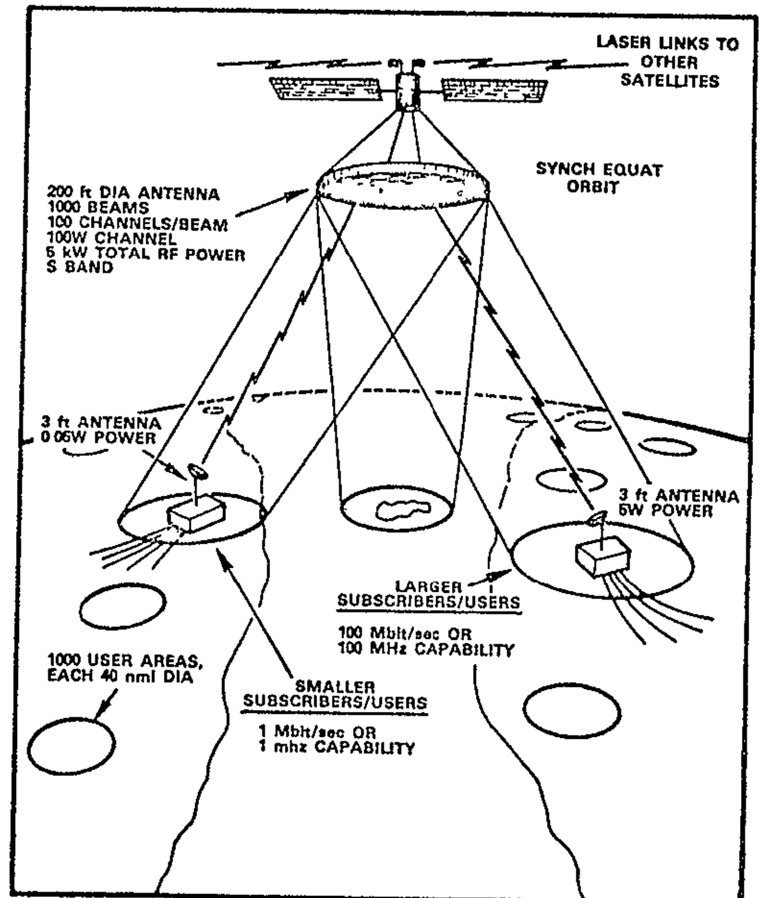
  To provide a National or Intelsat adjunct network with capability to serve small-antenna users.

- **RATIONALE**

  Current satellites require very large antennas and therefore have few entry points - not suited for "disadvantaged" users.

- **CONCEPT DESCRIPTION**

  Large multibeam antenna satellites link facsimile, voice, data, and teletype terminals with low power and small antennas. Satellite is a multi-channel processing repeater



- **CHARACTERISTICS**

• WEIGHT	20,000 lb
• SIZE	200-ft dia antenna
• RAW POWER	15 kW
• ORBIT	Synch. Equat
• CONSTELLATION SIZE	4
• RISK CATEGORY	I (Low)
• TIME FRAME	1990
• IOC COST (Space only)	1.1 B

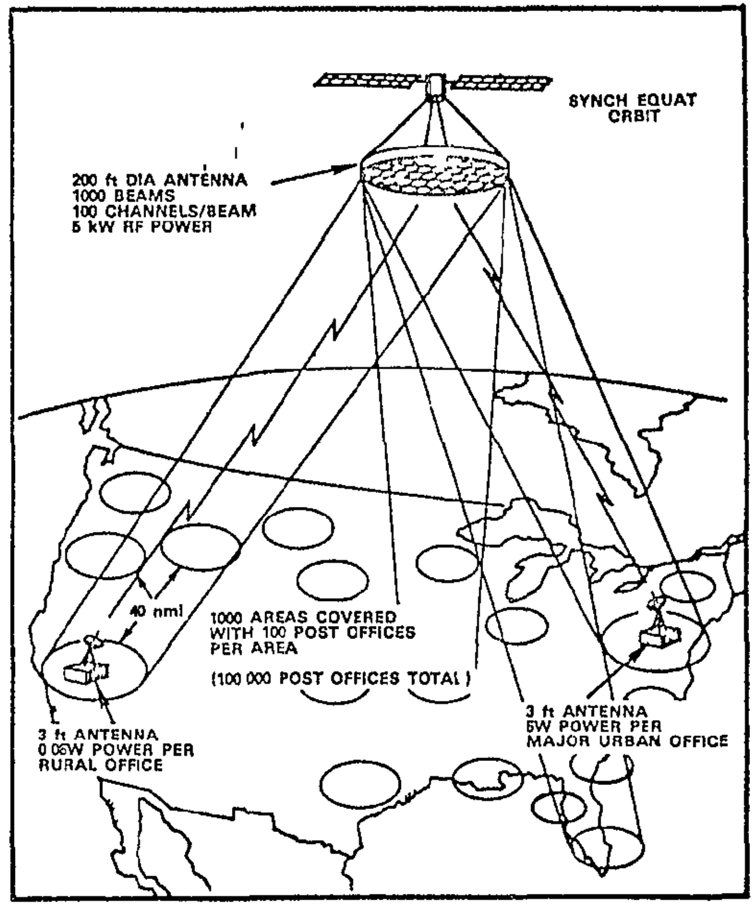
- **PERFORMANCE**

  400,000 channels of 1 Mbit/sec or 1 MHz capability serviced in 4000 areas worldwide, with 0.05-W transmitters and 3-ft antennas at user terminals.

- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and large tug or SEPS
• ON-ORBIT OPERATIONS	Automated or manual servicing unit; assembly on orbit
• SUBSYSTEMS	Attitude control; antenna; processor
• TECHNOLOGY	Large multibeam antenna; multi-channel transponder; LSI processor; multiple-access techniques
• OTHER	

ELECTRONIC MAIL TRANSMISSION (CC-4)



- **PURPOSE**

  To speed up delivery and lower costs of most mail.
  To service thinly populated areas.

- **RATIONALE**

  Delivery of physical letters is slow and needless in most cases when locally reproduced facsimile could do.

- **CONCEPT DESCRIPTION**

  Page readers and facsimile printers at each post office read, transmit, receive, and reproduce mail. Satellite acts as multi-channel repeater.

- **CHARACTERISTICS**

• WEIGHT	20,000 lb
• SIZE	200-ft dia antenna
• RAW POWER	15 kW
• ORBIT	Synch. Equat.
• CONSTELLATION SIZE	1
• RISK CATEGORY	I (Low)
• TIME FRAME	1990
• IOC COST (Space only)	430 M

- **PERFORMANCE**

  Transmits facsimile at 10 pages (8 1/2 x 11") per second per post office. Up to 100,000 post offices serviced in up to 50% of area of U. S. A. Total service = 100 billion pages/day.

- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and large tug or SEPS
• ON-ORBIT OPERATIONS	Automated or manual servicing unit; assembly on orbit
• SUBSYSTEMS	Attitude control; antenna; processor
• TECHNOLOGY	Large multibeam antenna; multi-channel transponder; LSI processor; multiple-access techniques
• OTHER	None

DISASTER COMMUNICATIONS SET (CC-3)

- **PURPOSE**

  To provide communications, command, and control to disaster area emergency personnel.

- **RATIONALE**

  Lack of communications hampers quick and effective handling of emergencies.

- **CONCEPT DESCRIPTION**

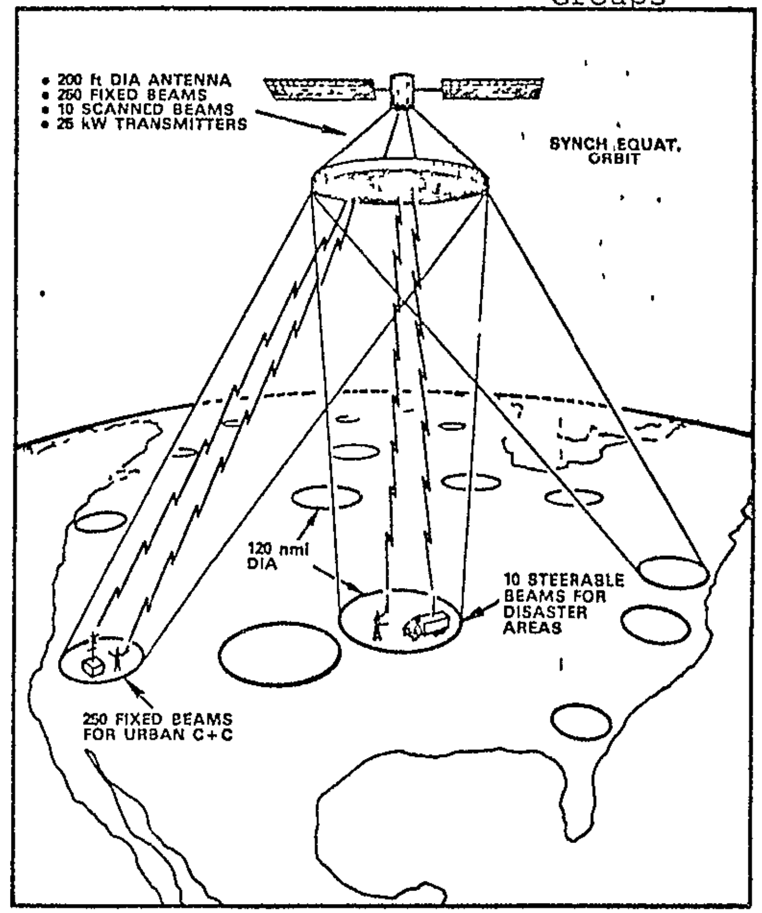
  Wrist 2-way transceivers connected to each other and to control centers through multi-channel Comsat. Anti-jam.

- **CHARACTERISTICS**

• WEIGHT	18,000 lb
• SIZE	200-ft dia antenna
• RAW POWER	75 kW
• ORBIT	Synch. Equat.
• CONSTELLATION SIZE	1
• RISK CATEGORY	I (Low)
• TIME FRAME	1990
• IOC COST	390 M

- **PERFORMANCE**

  Provides 10 disaster areas and 250 urban centers with 10 channels of voice communications each. Secure, anti-jam coded.



- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and large tug or SEPS
• ON-ORBIT OPERATIONS	Automated or manual servicing unit; assembly on orbit
• SUBSYSTEMS	Attitude control; antenna; processor
• TECHNOLOGY	Large multibeam antenna; multi-channel transponder; LSI processor; multi-access techniques
• OTHER	None

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Communication

PRODUCT/SERVICE: Down-Link Broadcast (Audio/Video)

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Powerful satellite in GEO stationary orbit makes reception possible in all U.S. areas with small antennas

Usuage:

Make TV available to all locations in U.S.

1) Weather Broadcasts (Remote Areas)
2) Disaster Warning
3) Entertainment
4) Education
5)

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

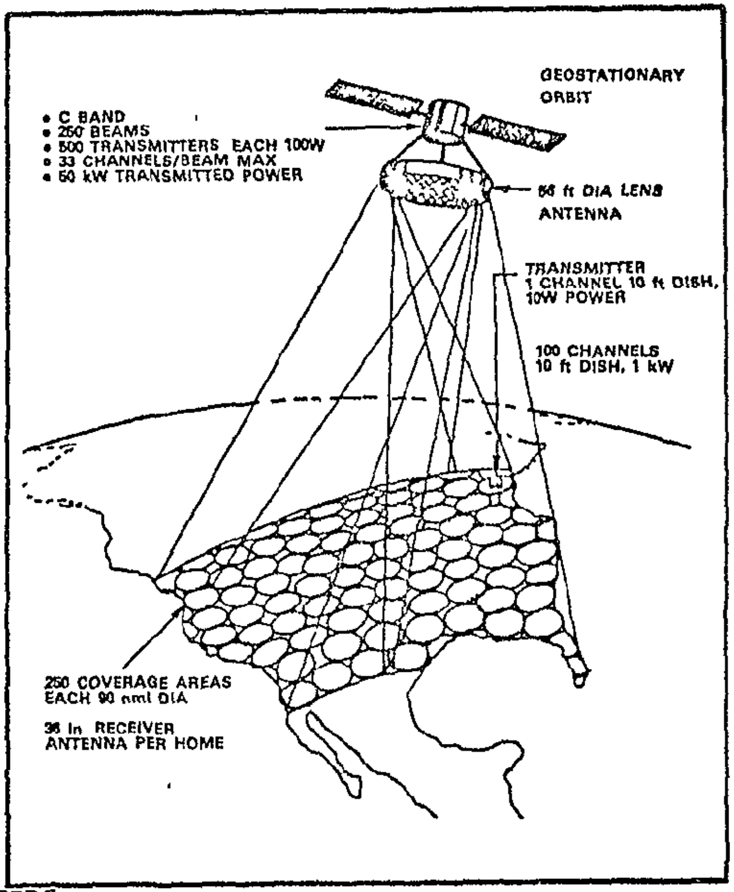
PRODUCT:

ADVANCED T.V. BROADCAST (CC-6)

- **PURPOSE**
  To make T.V. available to all locations in U.S., with small receiver antennas.

- **RATIONALE**
  Mountainous, rural, and remote areas currently have poor or no service due to line-of-sight transmissions.

- **CONCEPT DESCRIPTION**
  Powerful satellite in geostationary orbit makes reception possible in all U.S. areas with very small antennas.



- **CHARACTERISTICS**

• WEIGHT	14,000 lb
• SIZE	56-ft antenna
• RAW POWER	150 kW
• ORBIT	Geosynchronous
• CONSTELLATION SIZE	1
• RISK CATEGORY	I (Low)
• TIME FRAME	1990
• IOC COST (Space only)	460 M

- **PERFORMANCE**
  512 color T.V. channels broadcast to U S. land area, covered in 250 beams, each with 90-mi footprint. Local stations can distribute program anywhere.

- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and large tug or SEPS
• ON-ORBIT OPERATIONS	Automated or manned servicing
• SUBSYSTEMS	100 W output tube, 60-ft multibeam antenna
• TECHNOLOGY	Processor/filters
• OTHER	None

ORIGINAL PAGE IS
OF POOR QUALITY

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Vehicle Inspection/Communications

PRODUCT/SERVICE: National Motor Vehicle Inspection System

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

1) Install a microprocessor (similar to VW system perhaps) in each automobile manufactured which will sample conditions on key safety items in or on vehicle. Examples are tires, steering joints, lights, brakes, glass (for breaking), etc. A small broadcast system (ala Bekey) would allow periodic sampling by satellite and identification of unsafe vehicles nationwide. A condition uncorrected after some period of time would bring action by authorities. Savings in total state manhours unknown but substantial.

2) Distress Signal for Remote Use (Exploration, etc.)

3) Isolated Equipment Malfunction Warning

4)

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Navigation

PRODUCT/SERVICE: Location/Tracking of Icebergs in North Atlantic

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

At present, icebergs carried south from Greenland by the Labrador Current into the North Atlantic shipping lanes are tracked by air patrols which must re-locate each known iceberg every few days to provide reliable information to ships at sea. Projected positions can only be done with fair confidence for one or two days ahead, necessitating this cumbersome method.

Aerial drops of inexpensive transponders interrogated by satellites should significantly reduce the costs of the present program, with increased reliability and accuracy in iceberg position reports.

The present system is operated by the International Ice Patrol (a branch of the U.S. Coast Guard), with expenses shared by 19 maritime nations. The U.S. share is 12% of total annual costs of $1.3 million. Even with the present system, one ship is lost by iceberg collision about every 3 years; probable losses in each incident of the order of $10 million. I have no information on numbers of planes and personnel lost in the flights, which are often done in marginal weather conditions.

CHARACTERISTICS: (Essentially, this would be part of a VLA satellite system

TECHNOLOGY:

IOC: Late 1980's

SITE: either GSO, or multiple satellites in LEO

DIMENSION: 100 meters or larger antenna on satellite

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

Information

Communication

Up-Link Only

ENERGY MONITOR (CS-9)

- **PURPOSE**

  To measure energy flow at a very large number of points on distribution network

- **RATIONALE**

  Power programming and fine-tuning requires knowledge of energy status on network.

- **CONCEPT DESCRIPTION**

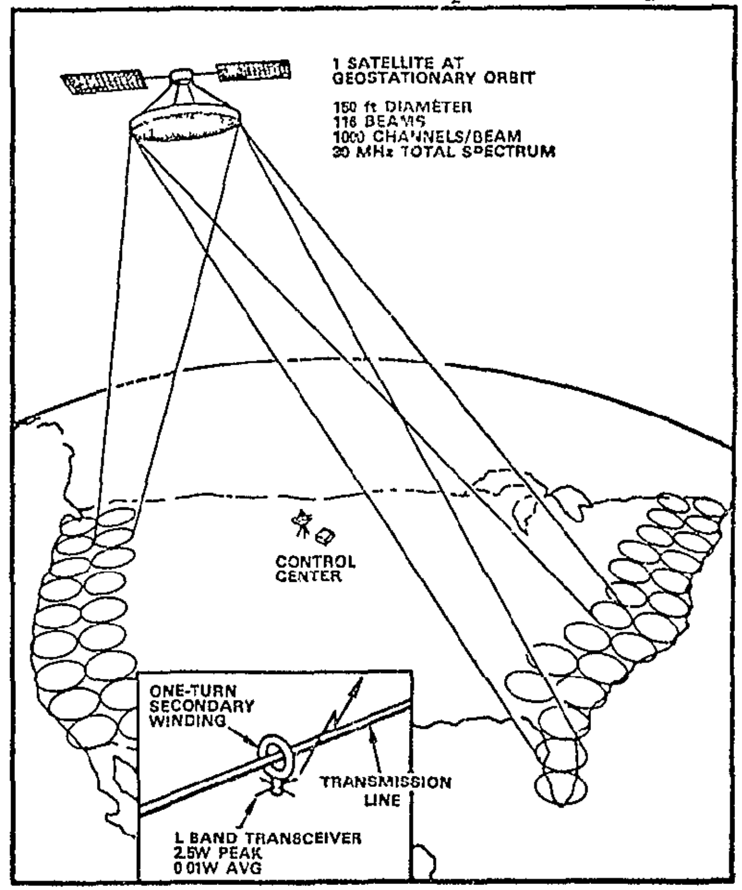
  Small L-band transmitters send instantaneous current, voltage, or power readings on network when queried sequentially by multi-channel/processing communications repeater

- **CHARACTERISTICS**

• WEIGHT	10,000 lb
• SIZE	150-ft dia
• RAW POWER	23 kW
• ORBIT	Geostationary
• CONSTELLATION SIZE	1
• RISK CATEGORY	1 (Low)
• TIME FRAME	1990
• IOC COST (Space only)	300 M

- **PERFORMANCE**

  Up to one billion points on energy generation and distribution network measured every hour.



- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and IUS/tug
• ON-ORBIT OPERATIONS	Automated or manual servicing, assembly
• SUBSYSTEMS	Attitude control, antenna, processor
• TECHNOLOGY	Multi-channel transponder, LSI processor
• OTHER	

GLOBAL SEARCH + RESCUE LOCATOR (CC-1)

- **PURPOSE**

  To locate emergency transmitters worldwide; to allow small, lightweight transmitters.

- **RATIONALE**

  Search for rescue is expensive and not always successful

- **CONCEPT DESCRIPTION**

  Coded, small transmitter in emergency package carried by traveling boats, aircraft. Signals received and transponded by satellites, and location computed by TDOA techniques

- **CHARACTERISTICS**

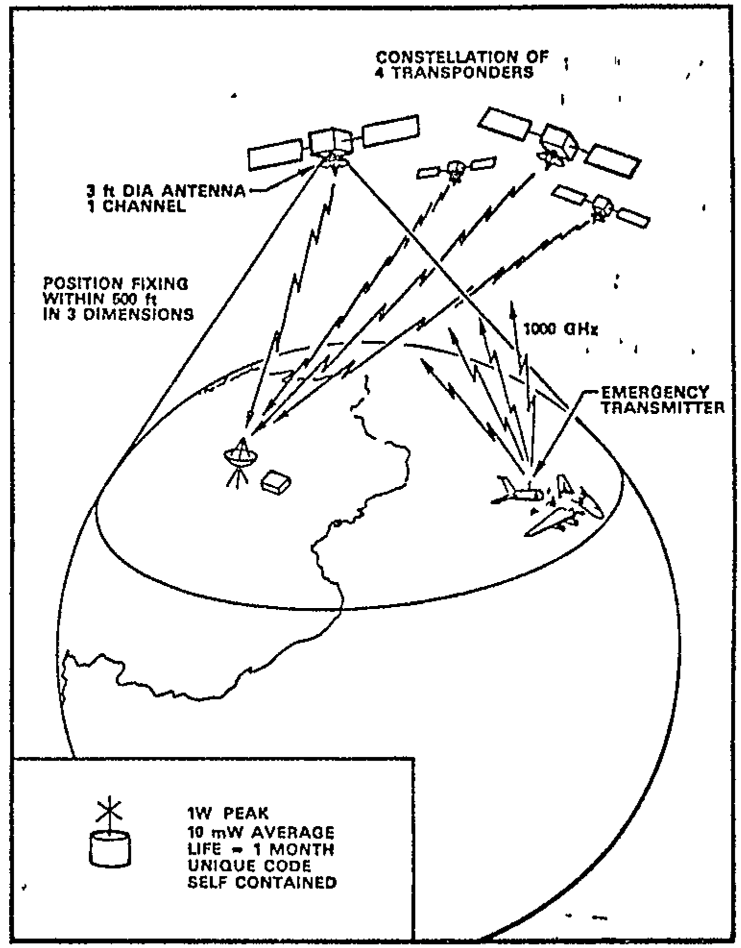
WEIGHT	1500 lb
SIZE	5 x 20 ft
RAW POWER	1 kW
ORBIT	Near-Synch., or Med. Alt.
CONSTELLATION SIZE	20
RISK CATEGORY	1 (Low)
TIME FRAME	1985
IOC COST (Space only)	350 M

- **PERFORMANCE**

  Location of up to 1000 simultaneous emergency transmitters to 500 ft in three coordinates, anywhere, worldwide

- **BUILDING BLOCK REQUIREMENTS**

TRANSPORTATION	Expendable or shuttle and tug
ON-ORBIT OPERATIONS	Automated servicing unit
SUBSYSTEMS	No unusual requirements
TECHNOLOGY	No unusual requirements
OTHER	None



14

NUCLEAR FUEL LOCATOR (CO-7)

Information
Communications
Up-Link Only

- **PURPOSE**
  To detect and locate all nuclear reactor fuel elements continuously wherever they are.

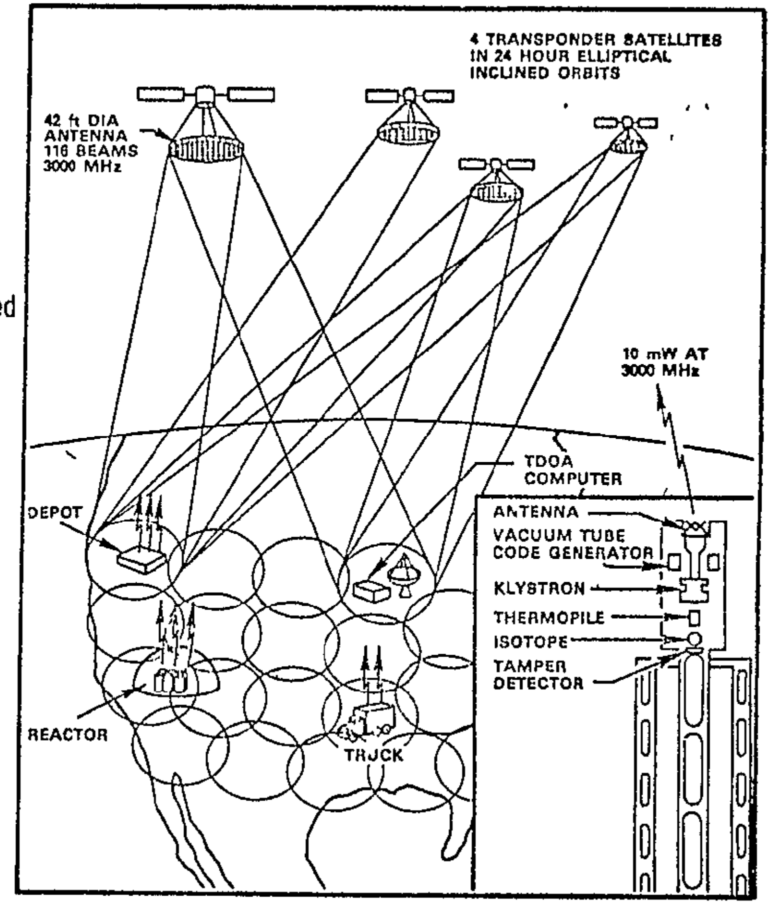
- **RATIONALE**
  Real-time monitoring of location of nuclear material needed to prevent proliferation of weapons and nuclear blackmail.

- **CONCEPT DESCRIPTION**
  Each assembly or container is tagged with a microwave generator in a tamper-indicating case. The uniquely coded signals are transponded by four satellites and the position computed by time-difference-of-arrival on the ground.

- **CHARACTERISTICS**

• WEIGHT	3000 lb
• SIZE	42 ft antenna
• RAW POWER	300 W
• ORBIT	Synch. Ellipt./Incl.
• CONSTELLATION SIZE	4
• RISK CATEGORY	I (Low)
• TIME FRAME	1985
• IOC COST (SPACE ONLY)	270 M

- **PERFORMANCE**
  Each fuel assembly identified and located to ±500 ft continuously, whether in a reactor building, in transit, or in storage, 10,000 assemblies tracked simultaneously.



- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and Tug
• ON-ORBIT OPERATIONS	Automated or manual service unit
• SUBSYSTEMS	Antenna, transponder
• TECHNOLOGY	Multibeam antenna - multi-channel transponder
• OTHER	LSI ground multi-channel cross-correlator receivers; high temperature and high radiation resistant vacuum tube transmitter and code generator; thermopile electrical generator; tamper alarm. Roof transponders.

ORIGINAL PAGE IS OF POOR QUALITY

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Robotic Functions

PRODUCT/SERVICE: Use of Comm. and/or Data System On-Orbit to Interface with Robotic Operators on Ground

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

(1) Maintenance of private & commerical facilities - a mobile robotic system with cleaning and pattern discrimination capability (microprocessor?) would be used to vacuum, clean walls, wash floors and maintain toilet areas. Single large data system linked by satellite can service many (hundreds) of these via communication link.

(2) Remote operation of Texas Tower type rigs for oil or mining operations.

(3) Remote massive farming of the oceans via satellite communication link.

(4) Remote control of ground explorations for minerals, etc. in different regions.

(5) Remote mining operations.

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

VEHICULAR SPEED LIMIT CONTROL (CS-10)

- **PURPOSE**

  To establish positive vehicle speed control zones in cities by radio control of vehicle engine governors

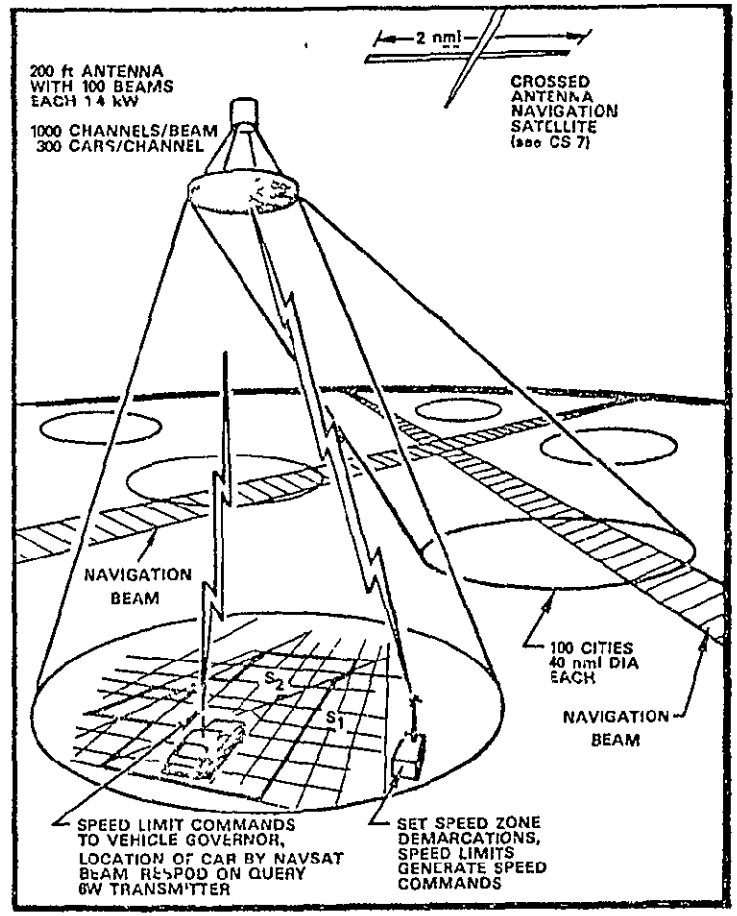
- **RATIONALE**

  Excessive speed is a major contributor to traffic accidents and injuries With positive control, speeding is impossible

- **CONCEPT DESCRIPTION** - Each vehicle has a small transceiver and a command receiver connected to a commandable speed governor Each vehicle determines its location using crossed antenna NAVSAT Speed commands are generated by computer on the ground

- **CHARACTERISTICS**

• WEIGHT	22,000 lb
• SIZE	200-ft dia antenna
• RAW POWER	430 kW
• ORBIT	Synch Equat.
• CONSTELLATION SIZE	1
• RISK CATEGORY	II (Medium)
• TIME FRAME	1990
• IOC COST (Space only)	470 M



- **PERFORMANCE**

  Vehicle speed controlled to ± 1 mph. Provision for one million cars in each of 100 cities (100 million total vehicles) Speed zones changed by program change.

- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and large tug or SEPS
• ON-ORBIT OPERATIONS	Automated or manual servicing unit; assemble in orbit
• SUBSYSTEMS	Attitude control, antenna, RF power DC power, channelized transponder
• TECHNOLOGY	Large multibeam antenna, power tubes, channelization techniques, large-scale multiple access
• OTHER	

ORIGINAL PAGE IS OF POOR QUALITY

SYNCHRONOUS METEOROLOGICAL SATELLITE (CO-12)

- **PURPOSE**

  To collect worldwide atmospheric data for global weather prediction.

- **RATIONALE**

  High resolution and frequent coverage of globe are needed for forecasts

- **CONCEPT DESCRIPTION**

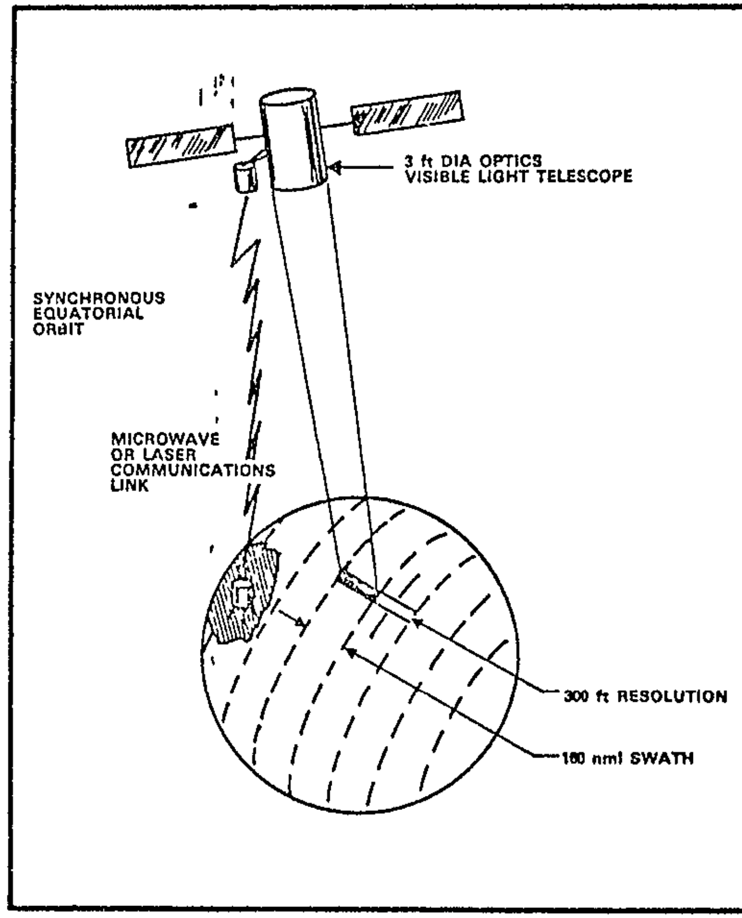
  Optical sensor with 1 meter mirror collects visible light data on gross meteorological features Same instrument makes spectrum measurements for detailed information on atmosphere.

- **CHARACTERISTICS**

• WEIGHT	3,000 lb
• SIZE	5 x 30 ft
• RAW POWER	1 kW
• ORBIT	Synch. Equat.
• CONSTELLATION SIZE	3
• RISK CATEGORY	I (Low)
• TIME FRAME	1985
• IOC COST (Space only)	190 M

- **PERFORMANCE**

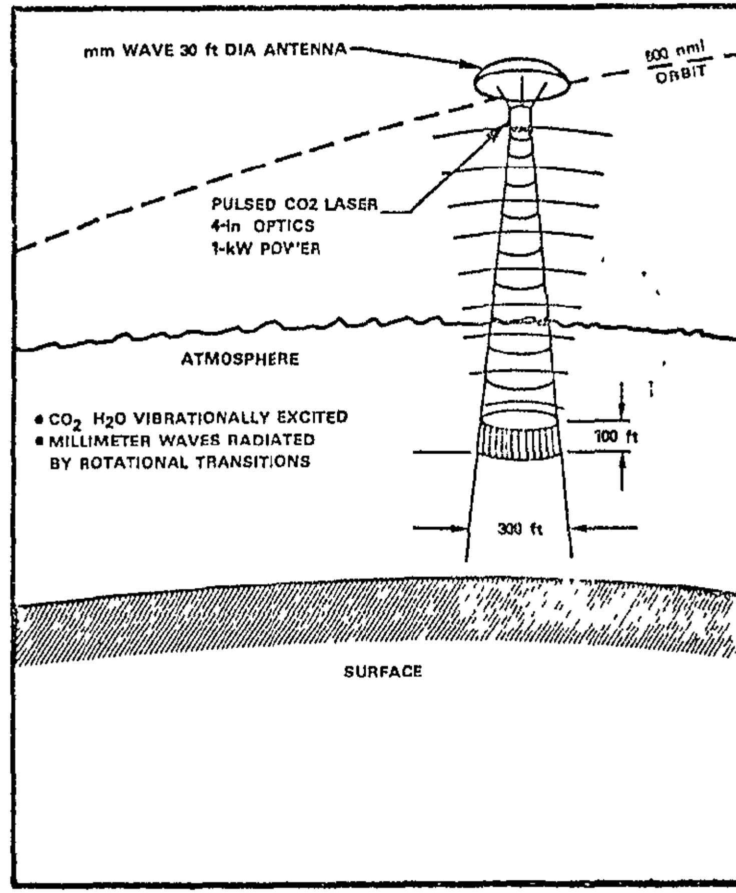
  Ground resolution 300-ft dia. Scan rate· earth coverage in 20 sec for clouds, etc. Detailed measurements of spectrum every 200 sec.



- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and tug
• ON-ORBIT OPERATIONS	Automated or manual servicing unit
• SUBSYSTEMS	Laser for communications
• TECHNOLOGY	Laser communications link. LSI computer
• OTHER	Weather prediction algorithm

ATMOSPHERIC TEMPERATURE PROFILE SOUNDER (CO-11)



- **PURPOSE**
  To measure actual profiles of temperature in the atmosphere.
- **RATIONALE**
  Weather prediction requires knowledge of temperature profiles, as well as other phenomena.
- **CONCEPT DESCRIPTION**
  Pulsed laser vibrationally excites CO_2 or H_2O molecules. Subsequent rotational transitions in the millimeter wave spectrum show temperature dependence which is measured by ratio of energy in several lines.
- **CHARACTERISTICS**

• WEIGHT	4000 lb
• SIZE	30-ft dia antenna
• RAW POWER	5 kW
• ORBIT	600-nmi polar
• CONSTELLATION SIZE	4
• RISK CATEGORY	III (Medium)
• TIME FRAME	1990
• IOC COST (SPACE ONLY)	250 M

- **PERFORMANCE**
  Entire atmosphere measured, with resolution of 300 ft horizontally and 100 ft vertically, every four hours. Emission lines and signal strength imprecisely defined at present.
- **BUILDING BLOCK REQUIREMENTS**

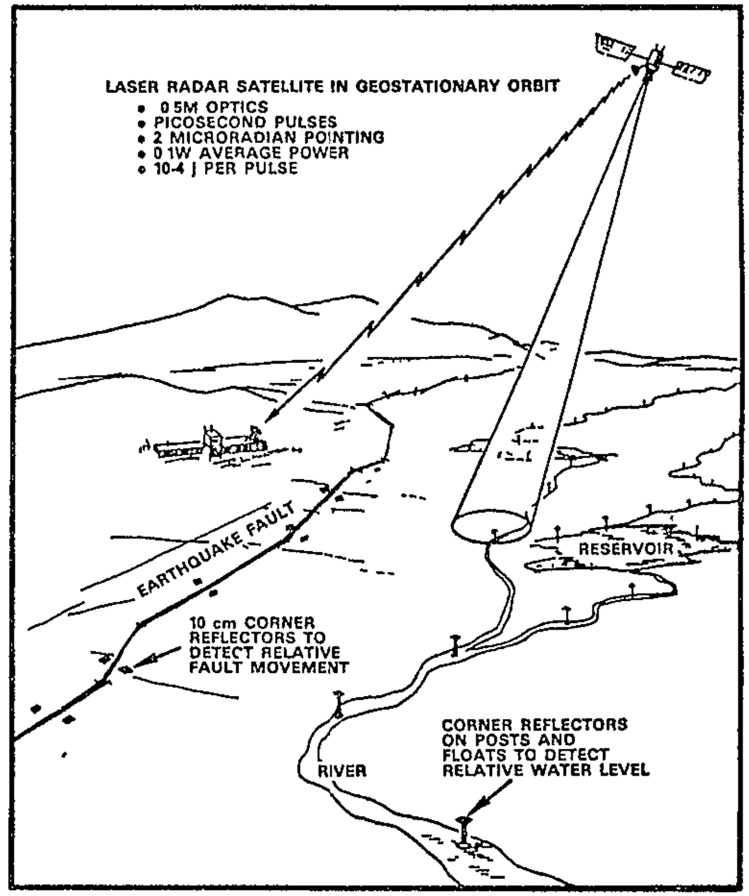
• TRANSPORTATION	Shuttle and tug/IUS
• ON-ORBIT OPERATIONS	Automated service unit/Shuttle-attached manipulator
• SUBSYSTEMS	Antenna, laser, attitude control
• TECHNOLOGY	Laser, power dissipation, antenna, pointing, sensitive heterodyne receiver
• OTHER	

ORIGINAL PAGE IS OF POOR QUALITY

WATER LEVEL AND FAULT MOVEMENT INDICATOR (CO-3)

- **PURPOSE**
  To make precision measurements in many places in rapid succession for aid in earthquake prediction, water resources establishment, disaster use, etc
- **RATIONALE**
  Prediction of earthquakes, floods, droughts, and accurate water resources would be of great social and economic benefit
- **CONCEPT DESCRIPTION**
  Picosecond (10^{-12} sec) pulsed laser radar in orbit obtains precision differential range measurements from corner reflectors implaced on both sides of faults, river banks and floats, etc.
- **CHARACTERISTICS**

WEIGHT	800 lb
SIZE	0.5 m optics
RAW POWER	250 W
ORBIT	Geostationary
CONSTELLATION SIZE	1
RISK CATEGORY	I (Low)
TIME FRAME	1985
IOC COST (SPACE ONLY)	50 M



- **PERFORMANCE**
  Relative range obtained to ± 0.3 millimeters at any number of points separated by 100 meters or more. 10^5 instrumented points can be measured every hour.
- **BUILDING BLOCK REQUIREMENTS**

TRANSPORTATION	Shuttle, IUS/Tug
ON-ORBIT OPERATIONS	Automated or manned servicing
SUBSYSTEMS	Picosecond receiver, transmitter, 2 μr pointing
TECHNOLOGY	Streak camera converter, mode locked laser and switch
OTHER	

OCEAN RESOURCES AND DYNAMICS SYSTEM (CO-4)

- **PURPOSE**
  To locate schools of fish and to map ocean dynamic signatures.

- **RATIONALE**
  Fish protein resource yield needs to be maximized due to world protein shortage. Mapping instruments needed.

- **CONCEPT DESCRIPTION**
  Temperature and emissivity differences in surface water caused by schools of fish, currents, and plankton concentrations are detected by the differences in their self-emission in the long-wave infrared.

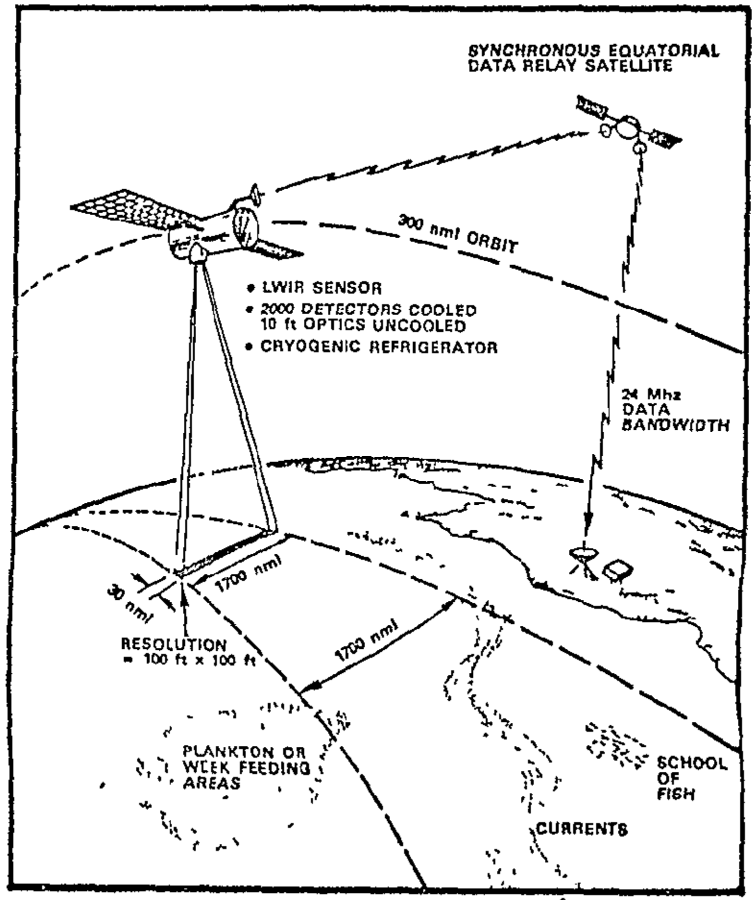
- **CHARACTERISTICS**

• WEIGHT	15,000 lb
• SIZE	10 x 60 ft
• RAW POWER	25 kW
• ORBIT	300 nmi polar
• CONSTELLATION SIZE	I
• RISK CATEGORY	I (Low)
• TIME FRAME	1985
• IOC COST (SPACE ONLY)	300 M

- **PERFORMANCE**
  100-ft resolution attained over all ocean surfaces every 12 hours. Sensitivity equivalent to 0.002 deg C achieved.

- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle
• ON-ORBIT OPERATIONS	Shuttle attached manipulator
• SUBSYSTEMS	Thermal dissipation, sensor, cryogenic cooler
• TECHNOLOGY	Large LWIR sensor; cryogenic refrigerator; LSI data processor
• OTHER	None



21

FIRE DETECTION (CO-2)

- **PURPOSE**

  To detect fires in remote regions, maintain surveillance of hot spots, fire perimeters.

- **RATIONALE**

  Fire damage can be minimized by early detection, and firefighting with knowledge of extent and progress

- **CONCEPT DESCRIPTION**

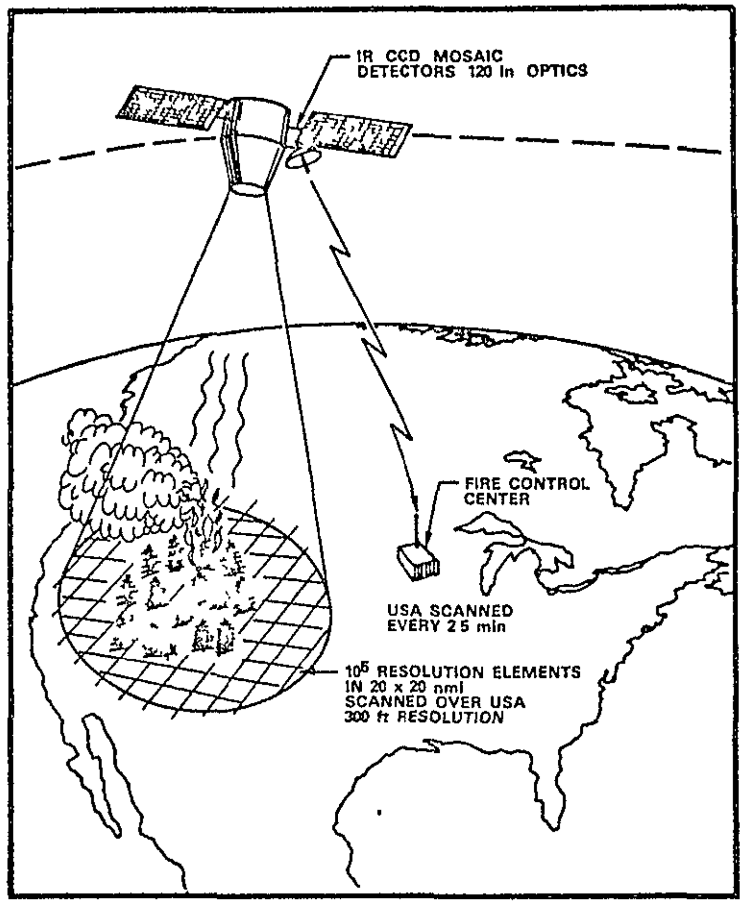
  Satellite with short and long wave infrared sensors detects fires at an early stage - transmits data to control center

- **CHARACTERISTICS**

• WEIGHT	25,000 lb
• SIZE	15 x 60 ft
• RAW POWER	2 kW
• ORBIT	Synch. Equat.
• CONSTELLATION SIZE	1
• RISK CATEGORY	I (Low)
• TIME FRAME	1985
• IOC COST (Space only)	230 M

- **PERFORMANCE**

  Detects fires as small as 10 x 10 ft Location accuracy < 300 ft Resolution ≈ 300 ft - U.S. coverage every 2 1/2 minutes



- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and large tug
• ON-ORBIT OPERATIONS	Automated or manual servicing unit
• SUBSYSTEMS	Attitude control; sensor
• TECHNOLOGY	Large optical mirror; LSI data processor; CCD focal plane
• OTHER	None

HIGH RESOLUTION EARTH MAPPING RADAR (CO-13)

- **PURPOSE**
  To provide maps of the surface with high resolution through cloud cover.

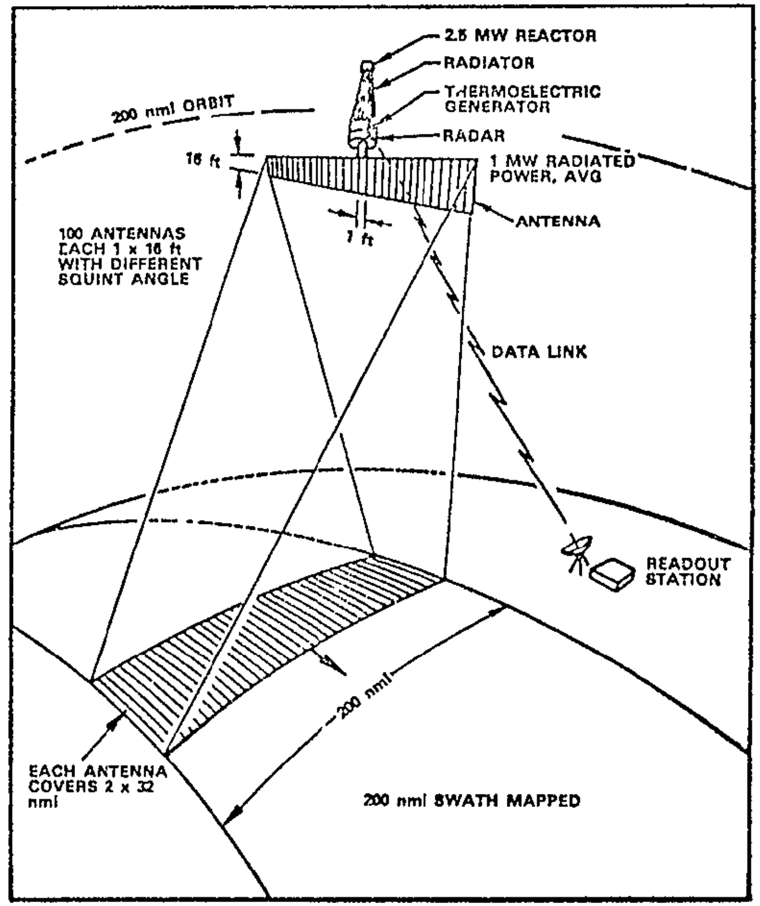
- **RATIONALE**
  Resources, pollution, crop, water, and other observations may be aided by high resolution and frequent coverage regardless of weather

- **CONCEPT DESCRIPTION**
  Synthetic array radar of very high power provides high resolution On-board image processing allows microwave data link for all weather capability

- **CHARACTERISTICS**

• WEIGHT	110,000 lb
• SIZE	16 x 100 ft
• RAW POWER	2 5 MW
• ORBIT	200 nmi polar
• CONSTELLATION SIZE	1
• RISK CATEGORY	II (Medium)
• TIME FRAME	1990
• IOC COST (Space only)	500 M

- **PERFORMANCE**
  200 nmi ground swath mapped to less than a few feet resolution once a day. U. S. covered every six days.



- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle
• ON-ORBIT OPERATIONS	Shuttle manipulator; servicing
• SUBSYSTEMS	Thermal, nuclear, power generator, radar
• TECHNOLOGY	High power transmitter; automated image processor, reactor, shielding
• OTHER	None

ORIGINAL PAGE IS OF POOR QUALITY

Information
Observations
Resources/Environmental Monitoring -

ADVANCED RESOURCES/POLLUTION OBSERVATORY (CO-1)

- **PURPOSE**

  To provide high quality, multispectral earth resources and pollution data.

- **RATIONALE**

  Integrated ERTS-like system, real-time data distribution to worldwide users, active sensors needed.

- **CONCEPT DESCRIPTION**

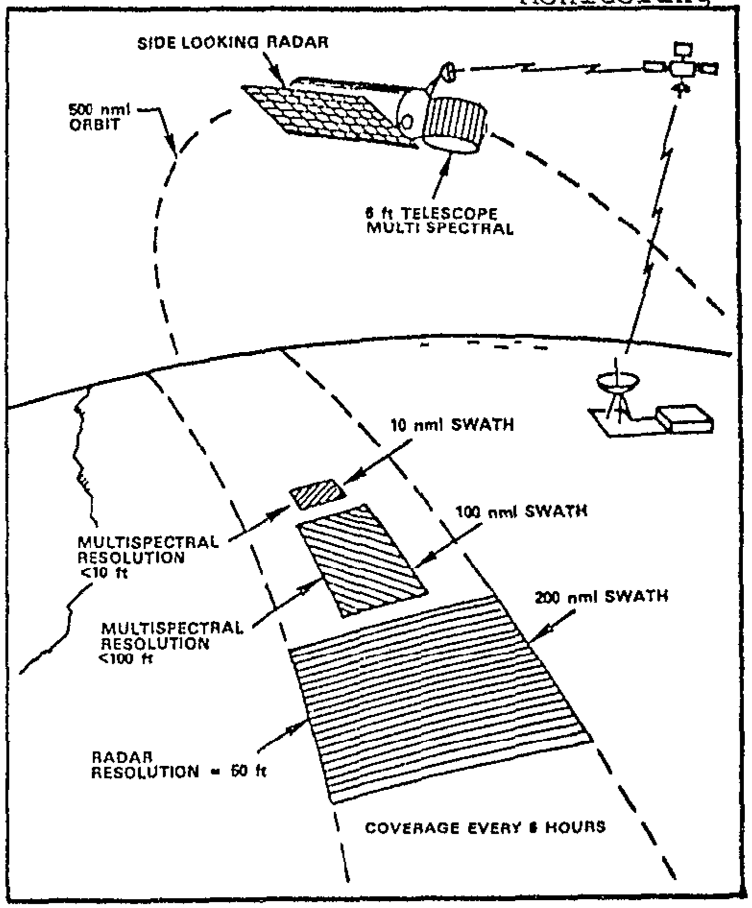
  Active and passive sensors, large aperture, high, medium, and low resolution imaging obtained in multispectral region and radar Data disseminated by laser link through relay satellite

- **CHARACTERISTICS**

  - WEIGHT — 30,000 lb
  - SIZE — 10 x 60 ft
  - RAW POWER — 12 kW
  - ORBIT — 500 nmi sun synch.
  - CONSTELLATION SIZE — 1
  - RISK CATEGORY — I (Low)
  - TIME FRAME — 1985
  - IOC COST (Space only) — 350 M

- **PERFORMANCE**

  Multispectral resolutions varying from < 10 to < 100 ft obtained worldwide.



- **BUILDING BLOCK REQUIREMENTS**

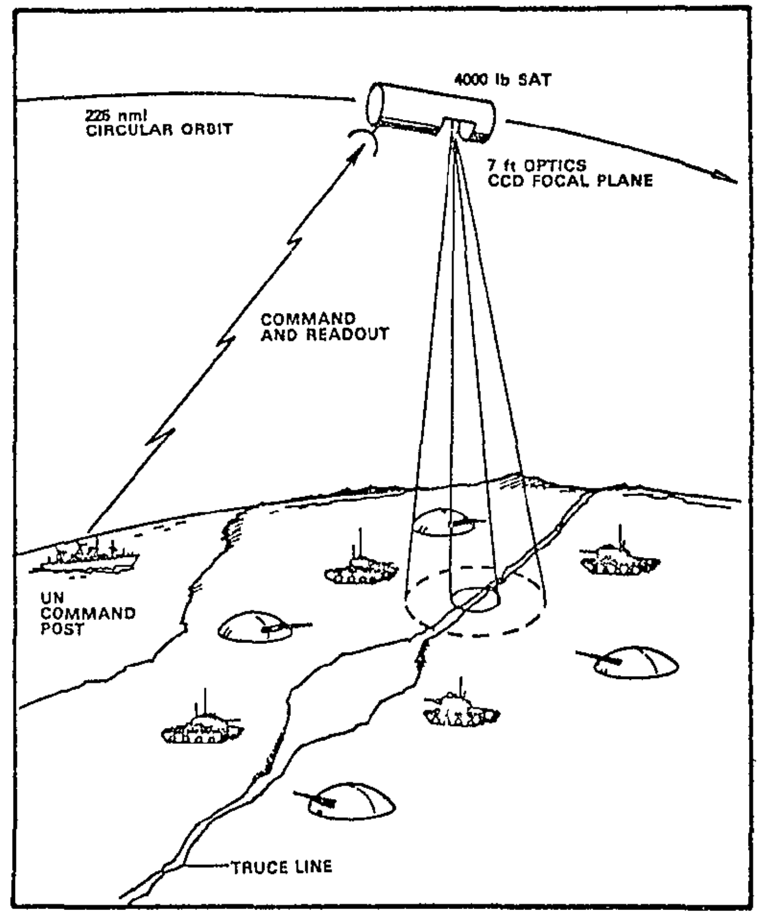
  - TRANSPORTATION — Shuttle and tug
  - ON-ORBIT OPERATIONS — Shuttle attached manipulator, servicing stages
  - SUBSYSTEMS — Guidance and navigation; attitude control; transmitter
  - TECHNOLOGY — Large radar antenna; high power tubes and modulator; LSI data processor
  - OTHER — None

USES: ENVIRONMENTAL MONITORING
- WATER POLLUTION
- AIR POLLUTION
- LAND USE
- CITY PLANNING
- MINING
- DUMPING

RESOURCES MONITORING
- MINERALS
- HYROLOGICAL
- FORESTS
- CROPS

U. N. TRUCE OBSERVATION SATELLITE (CO-6)

- **PURPOSE**
  Aid U N. teams to monitor truce agreements, particularly border zones, and weapon system dispositions such as missile launchers.
- **RATIONALE**
  U N will have responsibility for truce monitoring, but will be denied on-site capability in some cases Space systems are free from local control or interference
- **CONCEPT DESCRIPTION**
  One low altitude satellite with visible light optics for daytime monitoring and infrared optics for night-time operation.



- **CHARACTERISTICS**

• WEIGHT	4,000 lb
• SIZE	15 x 60 ft
• RAW POWER	3 kW
• ORBIT	225 nmi near-polar
• CONSTELLATION SIZE	1
• RISK CATEGORY	1 (Low)
• TIME FRAME	1985
• IOC COST (Space only)	90 M

- **PERFORMANCE**
  Ground resolution, <6 ft. (Visible) 120-ft I. R. Location accuracy, 300 ft Truce area covered twice a day
- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle
• ON-ORBIT OPERATIONS	Shuttle attached manipulator
• SUBSYSTEMS	Focal plane
• TECHNOLOGY	Similar to weather satellites and ERTS; CCD focal plane
• OTHER	

ORIGINAL PAGE IS OF POOR QUALITY

BORDER SURVEILLANCE (CO-8)

- **PURPOSE**
  To detect overt or covert attempts at crossing a border

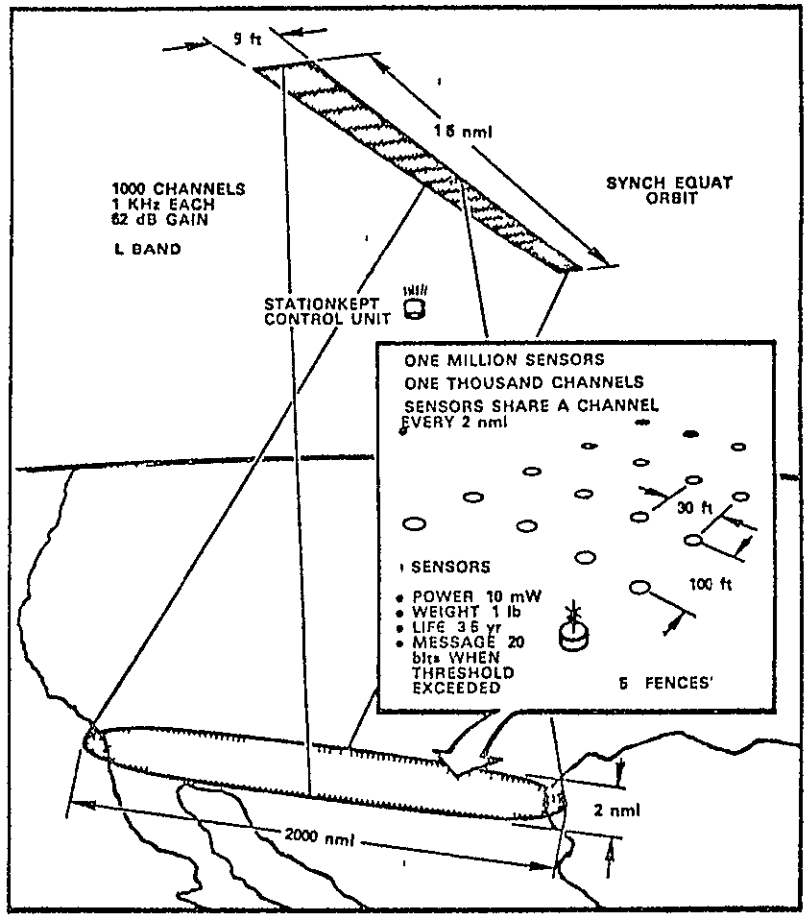
- **RATIONALE**
  Flow of illegal aliens and drug traffickers is a major problem. Detection is difficult along long, unpatrolled borders.

- **CONCEPT DESCRIPTION**
  Very many, very small seismic sensors are read out by a satellite with very large antenna Penetration causes vibrations which are picked up and correlated at a central site.

- **CHARACTERISTICS**

• WEIGHT	8000 lb
• SIZE	9000 ft x 9 ft
• RAW POWER	20 kW
• ORBIT	Synch Equat.
• CONSTELLATION SIZE	1
• RISK CATEGORY	II (Medium)
• TIME FRAME	1990
• IOC COST (Space only)	170 M

- **PERFORMANCE**
  Virtually all moving objects detected False alarms sorted by correlation between sensors and fences. Sensor life 3 5 years at one penetration attempt per sensor per month.

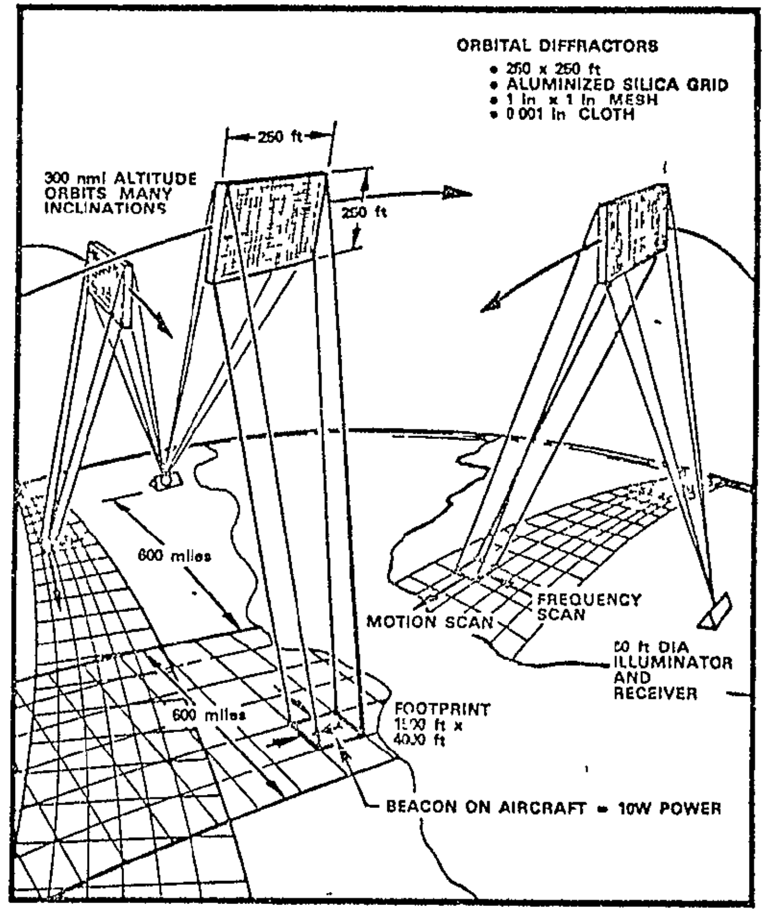


- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and tug
• ON-ORBIT OPERATIONS	Automated or manual assembly and servicing unit
• SUBSYSTEMS	Structure; attitude control; antenna
• TECHNOLOGY	Large passive microwave antenna - stationkeeping subsatellites; laser master measuring and control unit
• OTHER	Small, light, long-lived sensor units which are very cheap in mass production.

MULTINATIONAL AIR-TRAFFIC CONTROL RADAR (CO-5)

- **PURPOSE**
  To extend radar coverage beyond the line-of-sight for Air Traffic Surveillance, and avail other countries of the same satellites.
- **RATIONALE**
  Radars are costly and many are required today due to line-of-sight limits.
- **CONCEPT DESCRIPTION**
  Orbital diffracting passive arrays allow large coverage from a few central radars. Scanning accomplished by orbital motion and frequency shift.

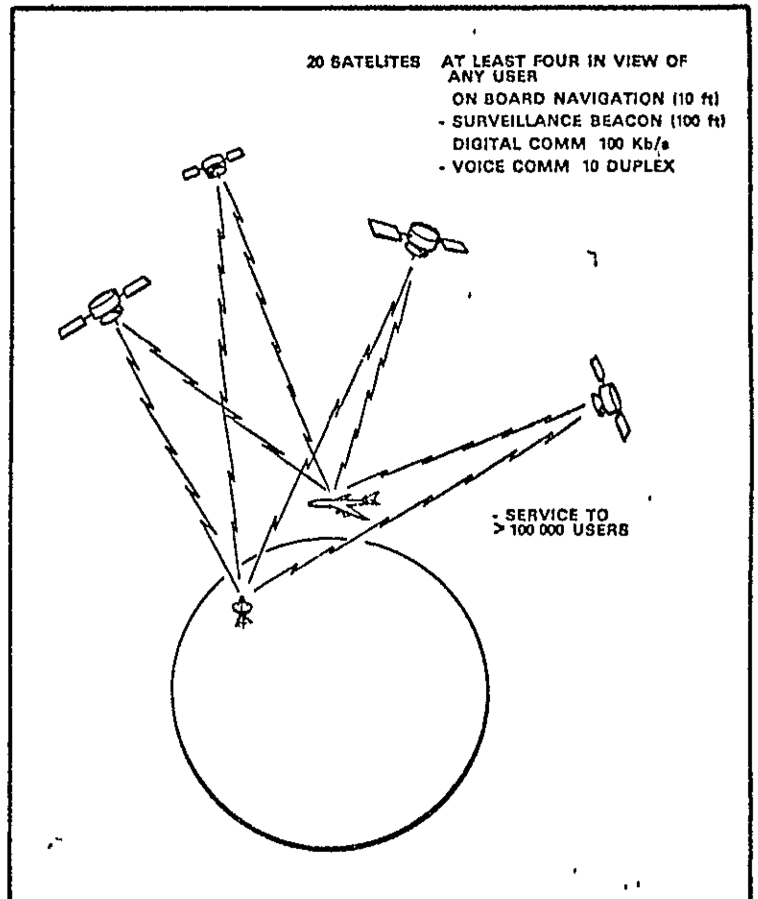


- **CHARACTERISTICS**
  - WEIGHT — 3,700 lb
  - SIZE — 250 x 250 ft
  - RAW POWER — 1 kW
  - ORBIT — 300 nmi, 35-50°
  - CONSTELLATION SIZE — 150
  - RISK CATEGORY — I (Low)
  - TIME FRAME — 1985
  - IOC COST (Space only) — 330 M
- **PERFORMANCE**
  All aircraft equipped with 10 W beacons detected reliably for enroute control every 4 min. U S A. covered with three radars. Smaller countries need only 1 - 2 radars
- **BUILDING BLOCK REQUIREMENTS**
  - TRANSPORTATION — Shuttle
  - ON-ORBIT OPERATIONS — Shuttle manipulator, automated or manual assembly/servicing
  - SUBSYSTEMS — Attitude control, structure
  - TECHNOLOGY — Ion thruster, structural rigidity
  - OTHER — None

27

E-0932R2
Information
Navigations
Aerial

TRANSPORTATION SERVICES SATELLITES (CC-5)



- **PURPOSE**
  Simultaneously satisfy traffic control, air surveillance, navigation, position fixing, command/control for multiplicity of uses.
- **RATIONALE**
  Similar and overlapping requirements by many agencies for precision navigation enable one comprehensive system to meet all needs for all users.
- **CONCEPT DESCRIPTION**
  Comsat transponders are used, with four in view of user at different angles/ranges, to provide TDOA position fixing and 2-way communications.
- **CHARACTERISTICS**

• WEIGHT	1400 lb
• SIZE	6 x 8 ft
• RAW POWER	600 W
• ORBIT	8000 nmi polar
• CONSTELLATION SIZE	20
• RISK CATEGORY	I (Low)
• TIME FRAME	1985
• IOC COST (Space only)	350 M

- **PERFORMANCE**
  100,000 users serviced, position to 30 ft, surveillance of beacon to 100 ft, digital communications of 100 kb/sec.
- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Expendable or shuttle and tug
• ON-ORBIT OPERATIONS	Automated servicing unit
• SUBSYSTEMS	No unusual requirements
• TECHNOLOGY	No unusual requirements
• OTHER	None

COASTAL ANTI-COLLISION PASSIVE RADAR (CO-9)

- **PURPOSE**
  Inexpensive and lightweight radar for all surface vessels - navigation; collision avoidance

- **RATIONALE**
  Conventional radar too expensive and interference prone Pleasure craft usually denied radar benefits.

- **CONCEPT DESCRIPTION**
  Illuminate seacoasts with scanning microwave beams from space Scanning receiving antennas on boats obtain range and angle data on hazards.

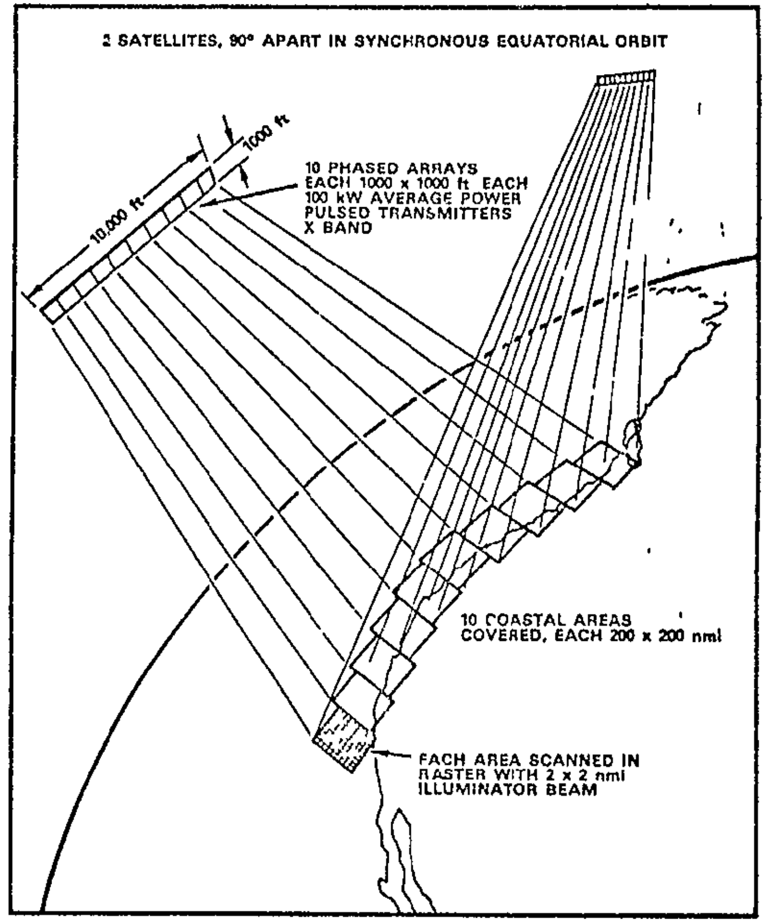
- **CHARACTERISTICS**

• WEIGHT	2,000,000 lb
• SIZE	1,000 x 10,000 ft
• RAW POWER	3 MW
• ORBIT	Synch Equat.
• CONSTELLATION SIZE	2
• RISK CATEGORY	II (Medium)
• TIME FRAME	1995
• IOC COST	10 B

- **PERFORMANCE**
  Relative location of all objects >100 m^2 within 12 nmi range 100 x 300 ft accuracy in 50^0 sector. 3 x 0 5 ft antenna in vessel Unlimited number of users

- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	LLV and large tug or large SEPS
• ON-ORBIT OPERATIONS	Automated or manual servicing unit; assembly in orbit
• SUBSYSTEMS	Structures; attitude control; antenna; power
• TECHNOLOGY	Large adaptive microwave antenna; high power transmitters; prime power source.
• OTHER	



ORIGINAL PAGE IS
OF POOR QUALITY

29

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Navigation

PRODUCT/SERVICE: Personal navigation wrist sets

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Large space antenna permits small low power wrist sets

Usuage:

To provide accurate relative position location with very inexpensive user equipment

1) Hiking
2) Exploration
3) Military
4) Automobiles

CHARACTERISTICS:

TECHNOLOGY:

SITE: GEO

TRANSPORTATION:

MASS: 18,000 lb

IOC:

DIMENSION: 200 ft ϕ antenna

SUPPLIES:

POWER: 75 KW

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

3c

NEAR-TERM NAVIGATION CONCEPT (CS-16)

- **PURPOSE**
  To provide reasonably accurate relative position location in the near term with very inexpensive user equipment.

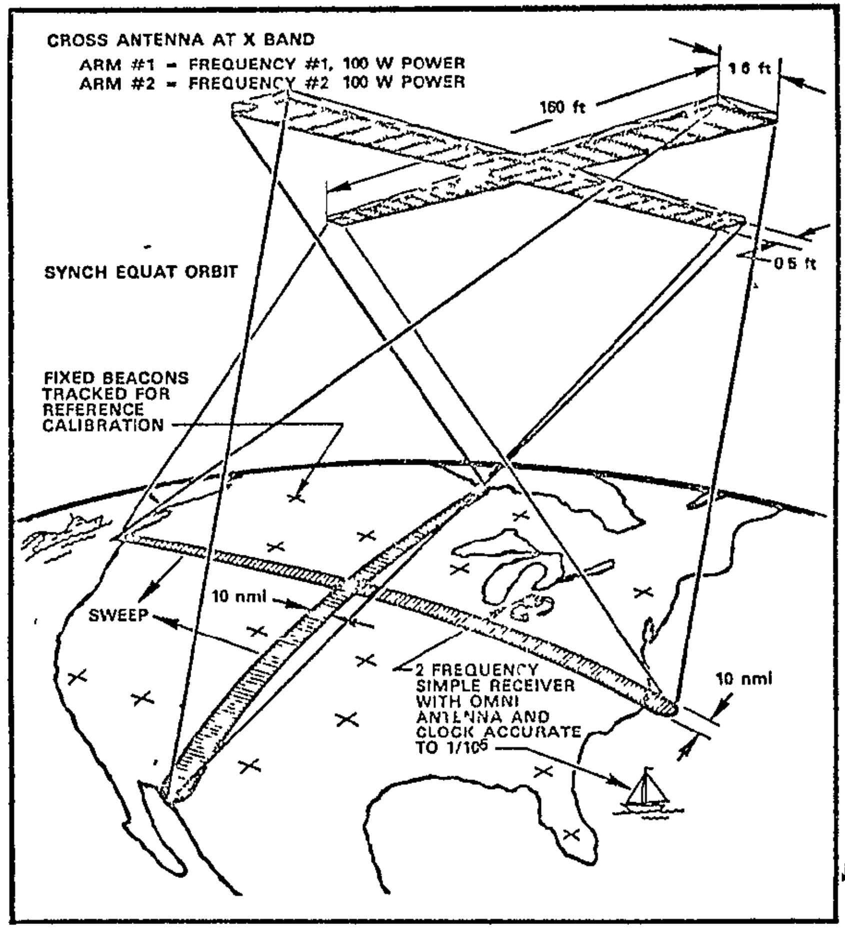
- **RATIONALE**
  Navigation system costs are dominated by user equipment costs. Wide popular need.

- **CONCEPT DESCRIPTION**
  Narrow beams are swept over the U.S. by phased arrays in space. Very simple receivers measure time elapsed between pulses received and display distances (N-S, E-W) to fixed points.

- **CHARACTERISTICS**
  - WEIGHT — 1,600 lb
  - SIZE — 160 ft cross
  - RAW POWER — 1 kW
  - ORBIT — Sync. Equat.
  - CONSTELLATION SIZE — 1
  - RISK CATEGORY — I (Low)
  - TIME FRAME — 1980
  - IOC COST — 90 M

- **PERFORMANCE**
  - User position located to 1/2 nmi every 10 sec anywhere in USA and 200 nmi beyond coastlines.
  - User receiver can cost less than $10 in mass production.

- **BUILDING BLOCK REQUIREMENTS**
  - TRANSPORTATION — Shuttle and IUS
  - ON-ORBIT OPERATIONS — Manned or automated assembly and servicing units
  - SUBSYSTEMS — Antenna, attitude control
  - TECHNOLOGY — ---
  - OTHER — LSI receivers



Information
Location
Individual

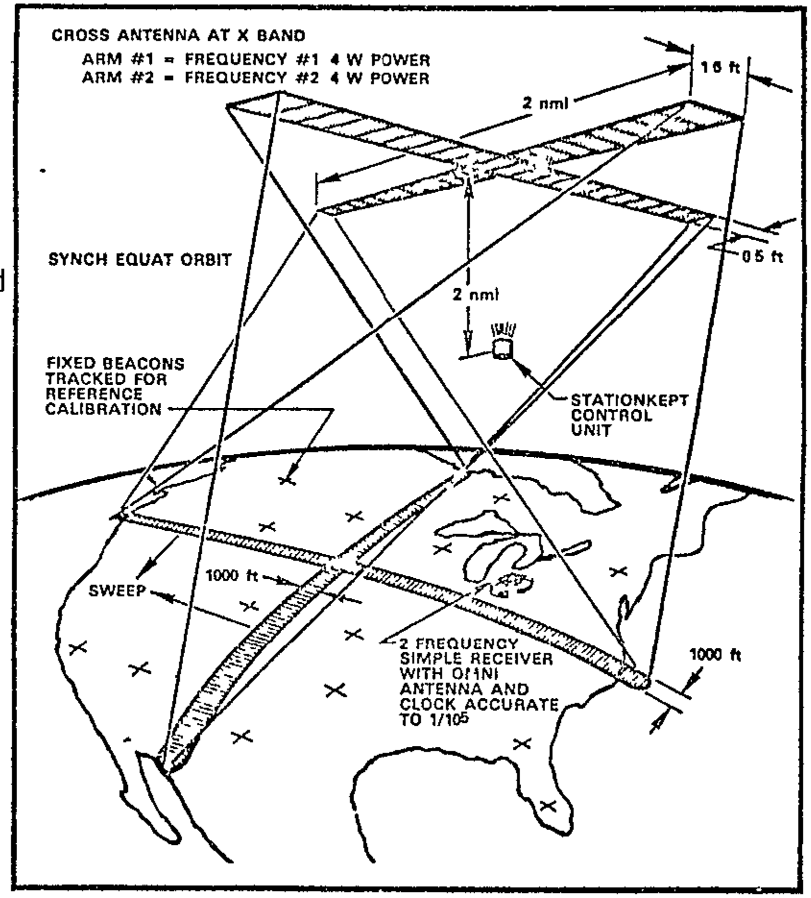
PERSONAL NAVIGATION WRIST SET (CS-7)

- **PURPOSE**
  To provide accurate relative position location with very inexpensive user equipment.

- **RATIONALE**
  Navigation system costs are dominated by user equipment costs.

- **CONCEPT DESCRIPTION**
  Narrow beams are swept over the U. S. by large phased arrays in space. Very simple receivers measure time elapsed between pulses received and display distances (N-S, E-W) to fixed point

- **CHARACTERISTICS**
  - WEIGHT — 3000 lb
  - SIZE — 2 nmi cross
  - RAW POWER — 2 kW
  - ORBIT — Sync. Equat
  - CONSTELLATION SIZE — 1
  - RISK CATEGORY — II (Medium)
  - TIME FRAME — 1990
  - IOC COST (SPACE ONLY) — 100 M



- **PERFORMANCE**
  - User position located to 300 ft every 10 sec relative to a fixed location < 100 nmi away.
  - User receiver can cost less than $10 in mass production.

- **BUILDING BLOCK REQUIREMENTS**
  - TRANSPORTATION — Shuttle and Tug
  - ON-ORBIT OPERATIONS — Manned or automated assembly and servicing units
  - SUBSYSTEMS — Antenna with independently stationkept subunits.
  - TECHNOLOGY — Ion thruster, adaptive RF phase control, laser master measuring unit
  - OTHER — LSI receivers

C-3

32

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Communication/Navigation

PRODUCT/SERVICE: Package Monitoring

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Large space antenna permits small low power wrist sets

Usuage:

Vehicle/Package Locator

1) Nuclear Products/Fuels
2) Package Tracing
3) Shipping Containers
4) Documents
5) Prisoners

CHARACTERISTICS:

TECHNOLOGY:

SITE: GEO

TRANSPORTATION:

MASS: 20,000 lb (total)

IOC: 1990

DIMENSION: 2 mi antenna

SUPPLIES:

POWER: 23 KW

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

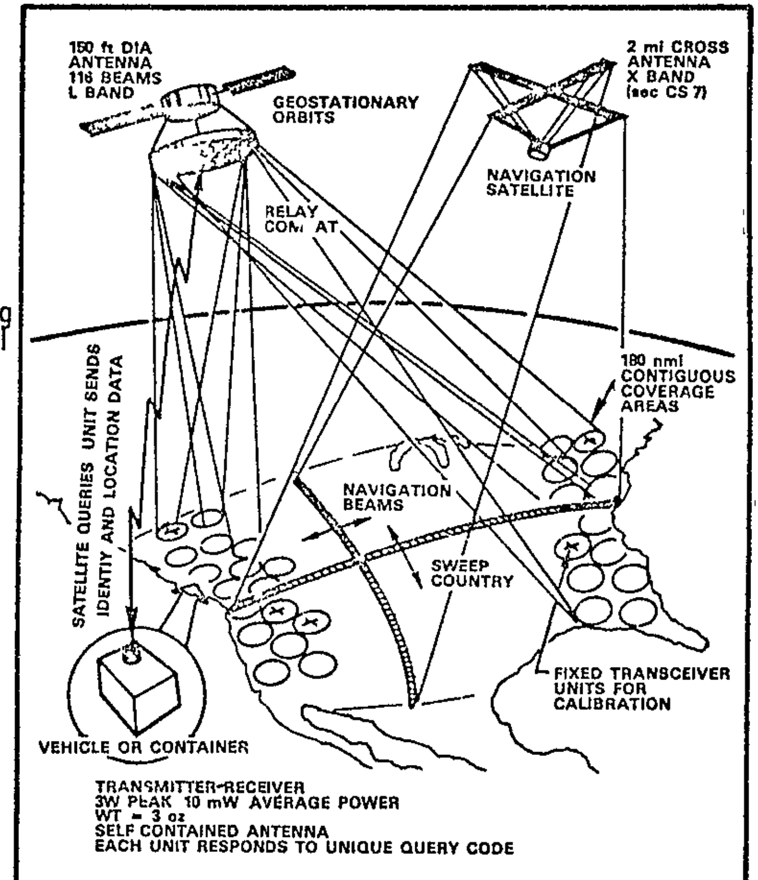
PRODUCT:

VEHICLE/PACKAGE LOCATOR (CC-12)

- **PURPOSE**
  To locate vehicles or articles in shipment continuously anywhere in U. S. A.

- **RATIONALE**
  To aid in prevention of theft or hijacking, increase efficiency, and minimize error in shipments

- **CONCEPT DESCRIPTION**
  A small transceiver is attached to (or enclosed in) each unit to be tracked. The unit determines its location using crossed antenna NAVSAT, and relays the data to a control center via a special Comsat when queried



- **CHARACTERISTICS**

• WEIGHT	20,000 lb (Total)
• SIZE	2-mi antenna
• RAW POWER	23 kW
• ORBIT	Geostationary
• CONSTELLATION SIZE	2
• RISK CATEGORY	II (Medium)
• TIME FRAME	1990
• IOC COST (Space only)	400 M

- **PERFORMANCE**
  Up to one billion vehicles or containers can be located ± 300 ft every hour anywhere in U. S. A. Location package could cost less than $10, weigh 3 ounces.

- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and large/tandem tug or SEPS
• ON-ORBIT OPERATIONS	Automated or manned assembly and servicing
• SUBSYSTEMS	Antenna attitude control, laser radar, channelizer/processor, stationkept antenna
• TECHNOLOGY	Phase control, LSI processor, multiple access technique, stationkept sub-units
• OTHER	Cheap - LSI - container - transponder

Information ,
Location
Vehicles

SPACE DEBRIS SWEEPER (CS-11)

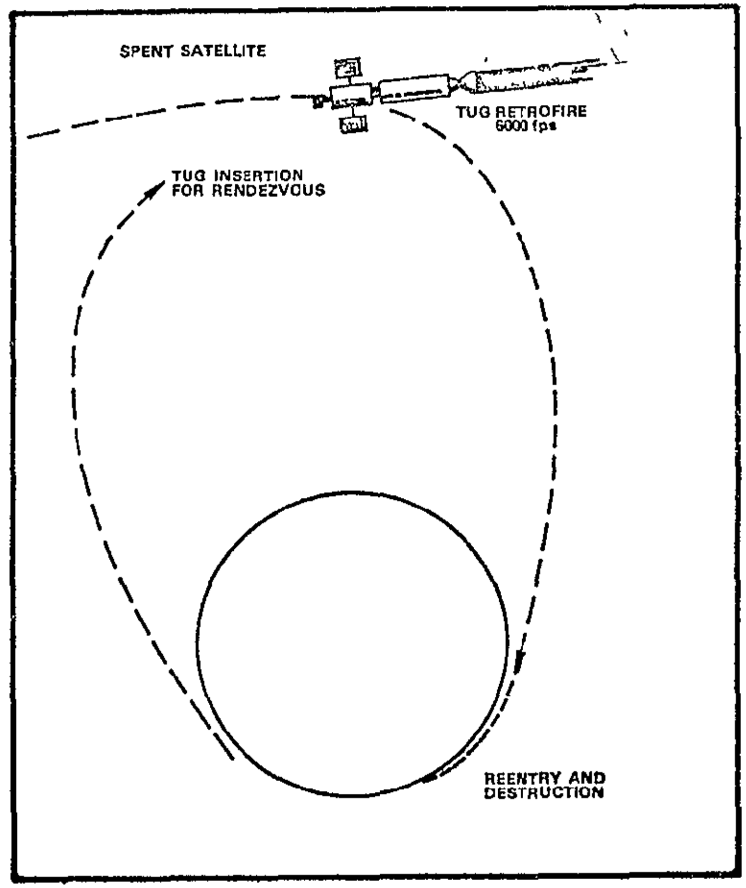
- **PURPOSE**
  To remove expended satellites and debris from synchronous equatorial corridor where they pose a long-term collision threat
- **RATIONALE**
  Synchronous equatorial corridor is becoming very crowded and could be dangerous in future.
- **CONCEPT DESCRIPTION**
  Use tug to impart ΔV to debris to drop its perigee to < 100 nmi Debris will reenter within weeks One orbit later, tug re-injects itself into SE orbit. Tug resupplied by shuttle
- **CHARACTERISTICS**

WEIGHT	500,000-lb propellant
SIZE	Tug
RAW POWER	--
ORBIT	Up to Synch. Equat.
CONSTELLATION SIZE	1
RISK CATEGORY	1 (Low)
TIME FRAME	1985
IOC COST (Space only)	0.5 M

- **PERFORMANCE**
  500,000 lb of propellant will deorbit 100 satellites of 5,000 lb each.

- **BUILDING BLOCK REQUIREMENTS**

TRANSPORTATION	Shuttle and tug
ON-ORBIT OPERATIONS	No unusual requirements
SUBSYSTEMS	No unusual requirements
TECHNOLOGY	No unusual requirements
OTHER	None



ORIGINAL PAGE IS OF POOR QUALITY

35

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Communications

PRODUCT/SERVICE: Voting & polling

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Large space antenna permits small low power wrist sets

Usage:

Voting & polling - very rapidly with large sample size

1) Individual Polling Units
2) Family Polling Units
   — Individual

Finance, Entertainment, Sales, Maintenance:

3) Business Surveys -Group
4) Local & National Elections - Individual
5) Seismic Sensing
6) Intrusion Sensing
7) Safety Monitoring
8) In-Situ Enfironmental Monitoring

Automated

CHARACTERISTICS:

TECHNOLOGY:

SITE: GEO

TRANSPORTATION:

MASS: 13,000 #

IOC: 1990

DIMENSION: 150 ft ϕ antenna

SUPPLIES:

POWER: 90 KW

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

Information
Sensor Polling
Individual

VOTING/POLLING WRIST SET (CC-7)

- **PURPOSE**

  To provide direct access to entire population for voting or polling purposes.

- **RATIONALE**

  Voting and polling are time-consuming processes, subject to many errors due to small sample size.

- **CONCEPT DESCRIPTION**

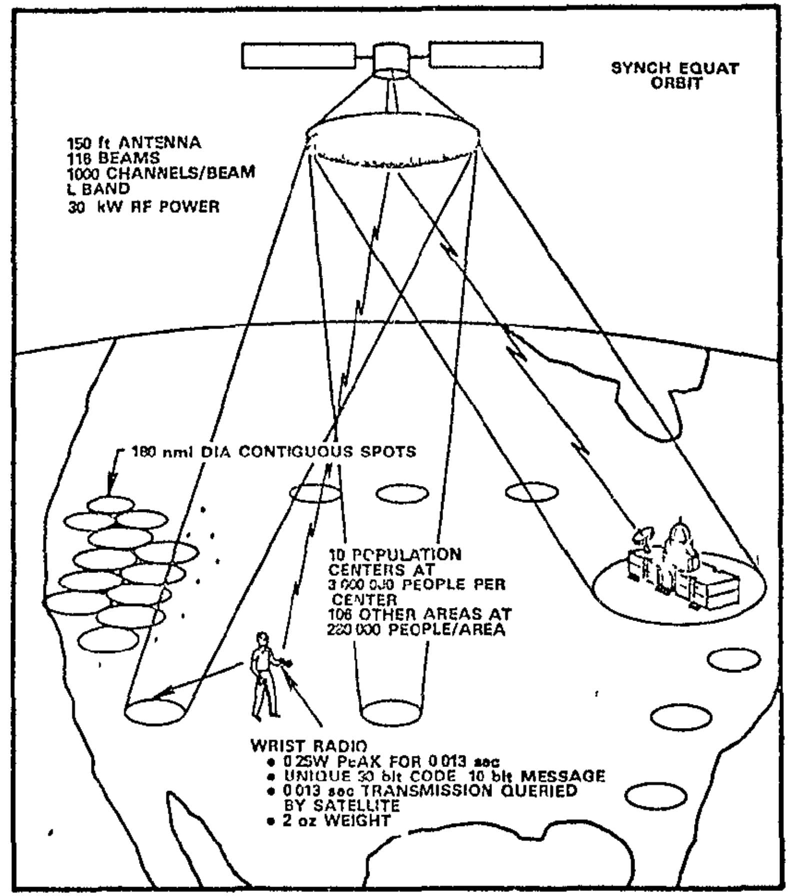
  Multi-channel satellite queries wrist radios, and relays responses to Washington from individual voters. Unique voter pseudo-random codes.

- **CHARACTERISTICS**

• WEIGHT	13,000 lb
• SIZE	150-ft dia antenna
• RAW POWER	90 kW
• ORBIT	Synch. Equat.
• CONSTELLATION SIZE	1
• RISK CATEGORY	I (Low)
• TIME FRAME	1990
• IOC COST (Space only)	300 M

- **PERFORMANCE**

  100,000,000 people polled/vote in one hour. Any 10-bit message relayed automatically upon query by satellite

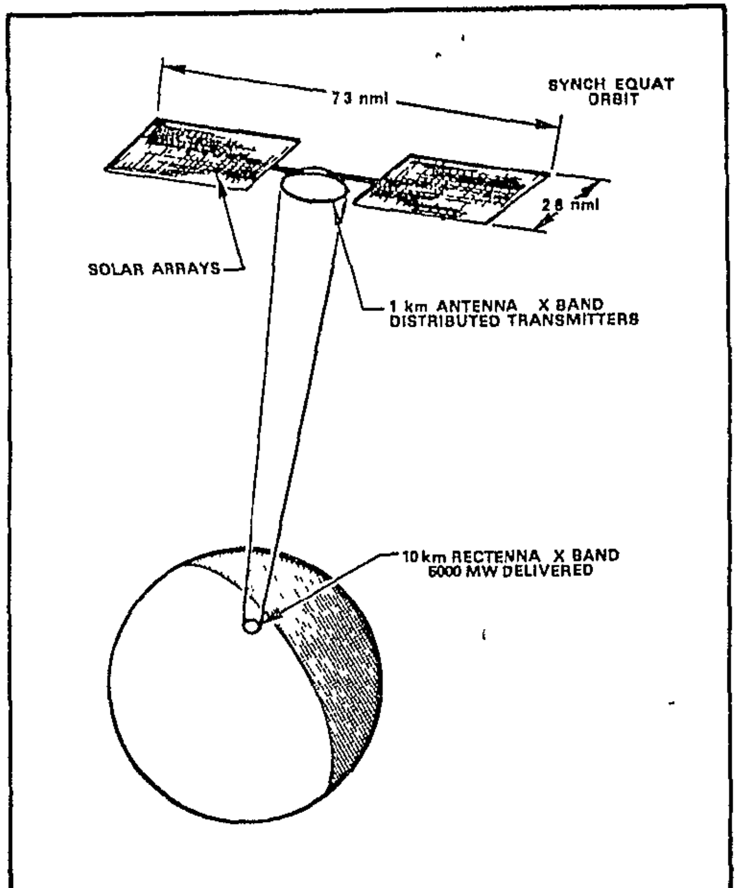


- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Shuttle and tandem tug
• ON-ORBIT OPERATIONS	Automated or manual servicing unit; assembly on orbit
• SUBSYSTEMS	Attitude control; antenna; processor
• TECHNOLOGY	Large multibeam antenna; multi-channel transponder; LSI processor; multiple-access techniques
• OTHER	LSI wrist transceiver

ENERGY GENERATION - SOLAR/MICROWAVE (CS-1)

Energy
SPS



- **PURPOSE**
  To provide abundant electrical power with little pollution.
- **RATIONALE**
  More and clean energy needed.
- **CONCEPT DESCRIPTION**
  Solar energy is collected, converted to microwave energy, and transmitted to earth, where it is rectified to DC by a rectenna.
- **CHARACTERISTICS**

• WEIGHT	40,000,000 lb
• SIZE	7.3 x 2 6 nmi
• RAW POWER	10,000 MW
• ORBIT	Synch Equat.
• CONSTELLATION SIZE	1
• RISK CATEGORY	IV (High)
• TIME FRAME	2000
• IOC COST (Space only)	61 B

- **PERFORMANCE**
  5,000 megawatts supplied to 10 km collector, with less than 500 MW lost as heat to the environment, at a cost of ≈ $1,500 per kW
- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	LLV and large tug and large SEPS
• ON-ORBIT OPERATIONS	Manned servicing unit; assemble in orbit
• SUBSYSTEMS	Attitude control; structures, power antenna
• TECHNOLOGY	Large economical solar arrays; large active microwave antenna; high power tubes; feeding and cross-connects
• OTHER	Rectenna on ground

ORIGINAL PAGE IS OF POOR QUALITY

ENERGY

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Reflectors/Illumination

PRODUCT/SERVICE: Illumination

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Large reflectors would be placed in LEO or GEO to reflect sunlight to areas requiring increased total insolation. Intensity could vary from a few lunar equivalents to full sunlight. Illuminated area would vary according to reflector altitude.

Applications: Increased agricultural yield, search and rescue, increased fishing yield, urban lighting

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

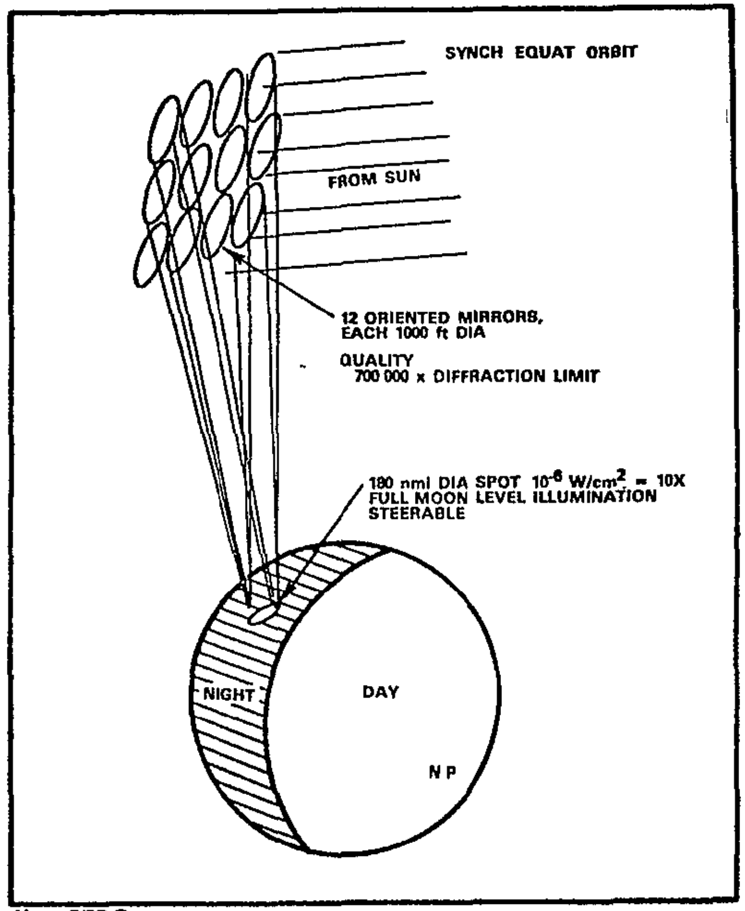
COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

NIGHT ILLUMINATOR (CS-6)



- **PURPOSE**

  To provide night lighting without earth-based energy, pollution, street lights, cables, trenches, etc.

- **RATIONALE**

  Alternative energy sources are needed.

- **CONCEPT DESCRIPTION**

  Large area reflectors in space reflect the image of the sun onto the earth. Multiple satellites used to minimize construction difficulties.

- **CHARACTERISTICS**
  - **WEIGHT** 100,000 lb
  - **SIZE** 12 mirrors each 1,000-ft dia
  - **RAW POWER** 1 2 kW
  - **ORBIT** Synch. Equat
  - **CONSTELLATION SIZE** 1
  - **RISK CATEGORY** II (Medium)
  - **TIME FRAME** 1990
  - **IOC COST** (Space only) 160 M

- **PERFORMANCE**

  Ten times full-moon level illumination at night provided to area 180 nmi dia (no clouds). Full moon level provided through moderate clouds.

- **BUILDING BLOCK REQUIREMENTS**
  - **TRANSPORTATION** Shuttle and large tug and/or SEPS
  - **ON-ORBIT OPERATIONS** Automated or manual servicing unit
  - **SUBSYSTEMS** Attitude control; mirrors, structure
  - **TECHNOLOGY** Large reflector; pointing; stationkeeping master control
  - **OTHER** None

E-0948R1

NUCLEAR WASTE DISPOSAL (CS-4)

- **PURPOSE**

  To permanently dispose of nuclear wastes without environmental damage.

- **RATIONALE**

  Wholesale use of nuclear generating plants for electric power will result in large amounts of highly toxic and long lived radioactive wastes

- **CONCEPT DESCRIPTION**

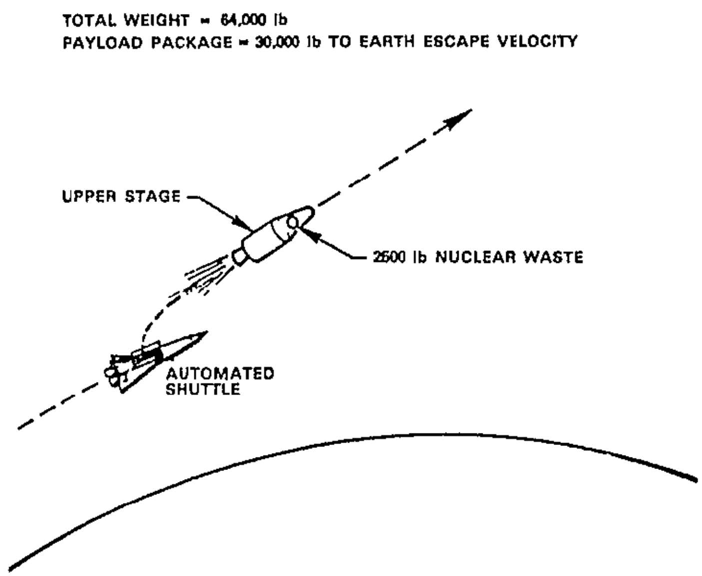
  Wastes are packaged in containers with shielding and cooling, and put into earth escape trajectories by shuttle and velocity stages.

- **CHARACTERISTICS**

• WEIGHT	64,000 lb
• SIZE	15 x 60 ft
• RAW POWER	---
• ORBIT	Escape
• CONSTELLATION SIZE	---
• RISK CATEGORY	II (Medium)
• TIME FRAME	1990 - 2000
• IOC COST (SPACE ONLY)	430 M

- **PERFORMANCE**

  2500 lb of waste per flight at $15 million per flight ($6000/lb). Cost increase to electrical consumer ≈ 2%.

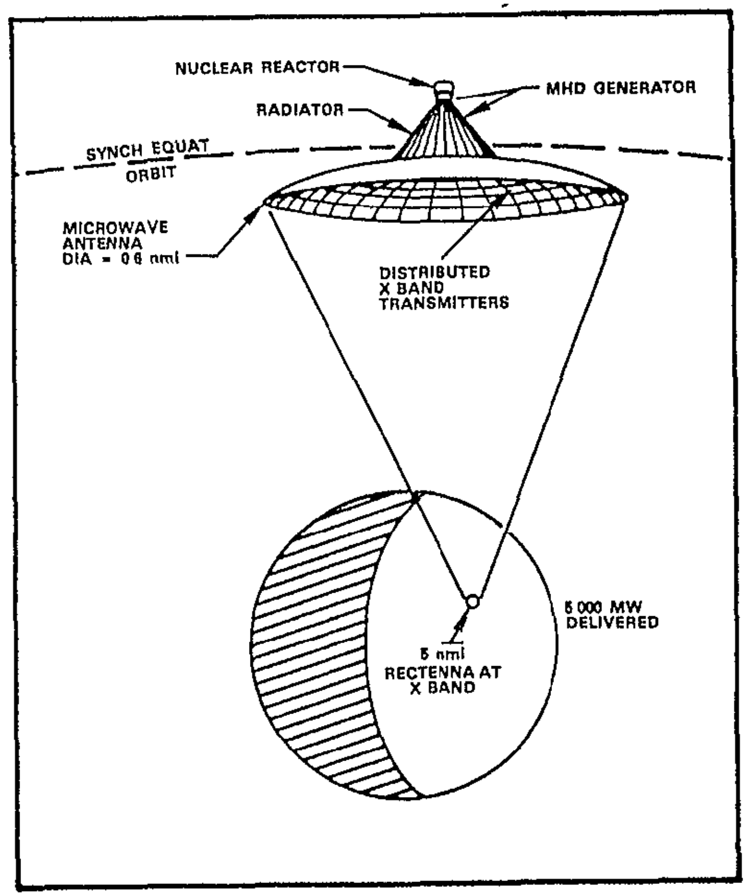


- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	Automated shuttle and large tug
• ON-ORBIT OPERATIONS	Safety/abort - backup systems
• SUBSYSTEMS	Shielding/encapsulation; abort systems
• TECHNOLOGY	Thermal control; structural package integrity; recovery techniques
• OTHER	

ENERGY GENERATION - NUCLEAR/MICROWAVE (CS-3)

- **PURPOSE**
  To generate and deliver electrical energy without pollution or hazard.
- **RATIONALE**
  Power is needed which requires no radioactive material on earth, produces no atmospheric heating, and no resource consumption.
- **CONCEPT DESCRIPTION**
  A breeder reactor, MHD power generator, microwave transmitter, and microwave antenna are used to beam energy to a ground receiver Fuel breeding supplies fuel



- **CHARACTERISTICS**

WEIGHT	TBD
SIZE	3,600-ft dia
RAW POWER	10,000 MW
ORBIT	Synch. Equat.
CONSTELLATION SIZE	1
RISK CATEGORY	IV (High)
TIME FRAME	2000
IOC COST (Space only)	TBD

- **PERFORMANCE**
  5,000 Megawatts delivered power continuously - with sufficient fuel breeding for a life of at least 1000 years

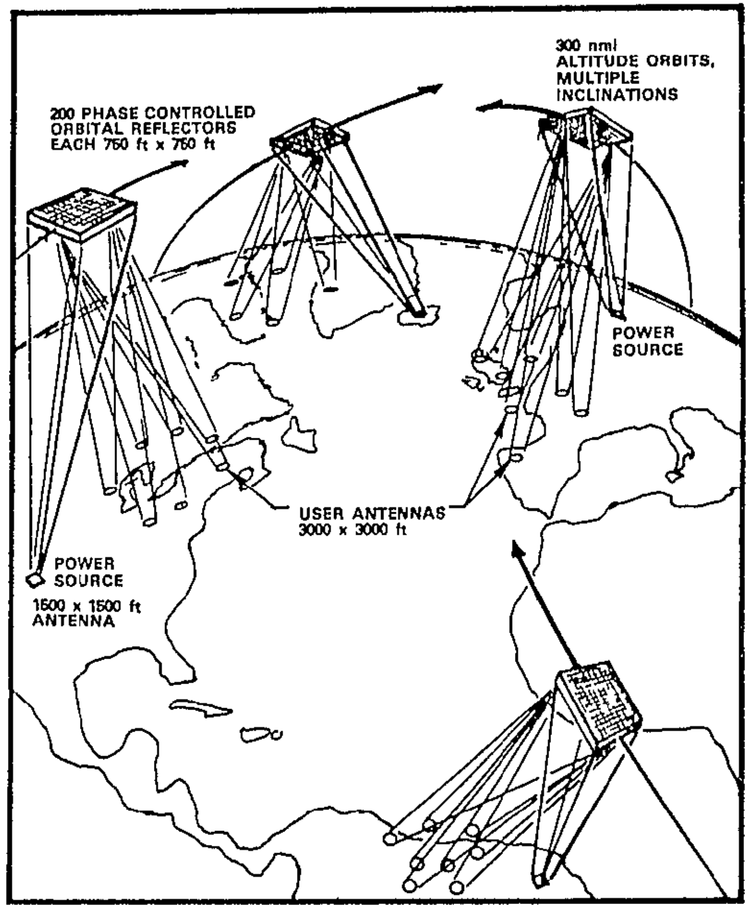
- **BUILDING BLOCK REQUIREMENTS**

TRANSPORTATION	LLV and large tug and large SEPS
ON-ORBIT OPERATIONS	Manned service unit, automated servicing unit; assemble in orbit
SUBSYSTEMS	Structure; attitude control; antenna; reactor; power unit
TECHNOLOGY	Large active microwave antenna; large reactor; heat radiator; MHD power generator; pointing and tracking sensor
OTHER	Rectenna on ground, safety

42

MULTINATIONAL ENERGY DISTRIBUTION (CS-8)

- **PURPOSE**
  To distribute energy to small-city users without transmission lines, and serve many nations simultaneously.
- **RATIONALE**
  Transmission lines are fixed, have an environmental impact, and limited capacity to feed growing communities or developing nations without large networks or large losses
- **CONCEPT DESCRIPTION**
  Phase-controlled array reflectors in low orbit sequentially relay remote source power to 100 user antennas per satellite Power is rectified at substation receiving arrays and filtered.
- **CHARACTERISTICS**
  - WEIGHT — 34,000 lb
  - SIZE — 750 x 750 ft
  - RAW POWER — 20 kW
  - ORBIT — 300 nmi several incl.
  - CONSTELLATION SIZE — 200
  - RISK CATEGORY — IV (High)
  - TIME FRAME — 2000
  - IOC COST (Space only) — 5.8 B
- **PERFORMANCE**
  1000 user areas in U S A powered with 100 MW each in rapid (1/120 sec) sequence from 10 power station source antennas Scanning loss < 1%, overall efficiency >55% 3000-ft square receiver with 1 7 nmi square guard fence suffices for user.



- **BUILDING BLOCK REQUIREMENTS**
  - TRANSPORTATION — Shuttle
  - ON-ORBIT OPERATIONS — Shuttle attached manipulator; manual or automated servicing unit
  - SUBSYSTEMS — Attitude control, stationkeeping units, phase control, figure control
  - TECHNOLOGY — Ion thrusters, phase control, measurement and control lidar, LSI processor
  - OTHER

ORIGINAL PAGE IS
OF POOR QUALITY

43

POWER RELAY SATELLITE (CS-15)

- **PURPOSE**
  To provide for transmission of electrical power from remote regions, minimizing environmental impact

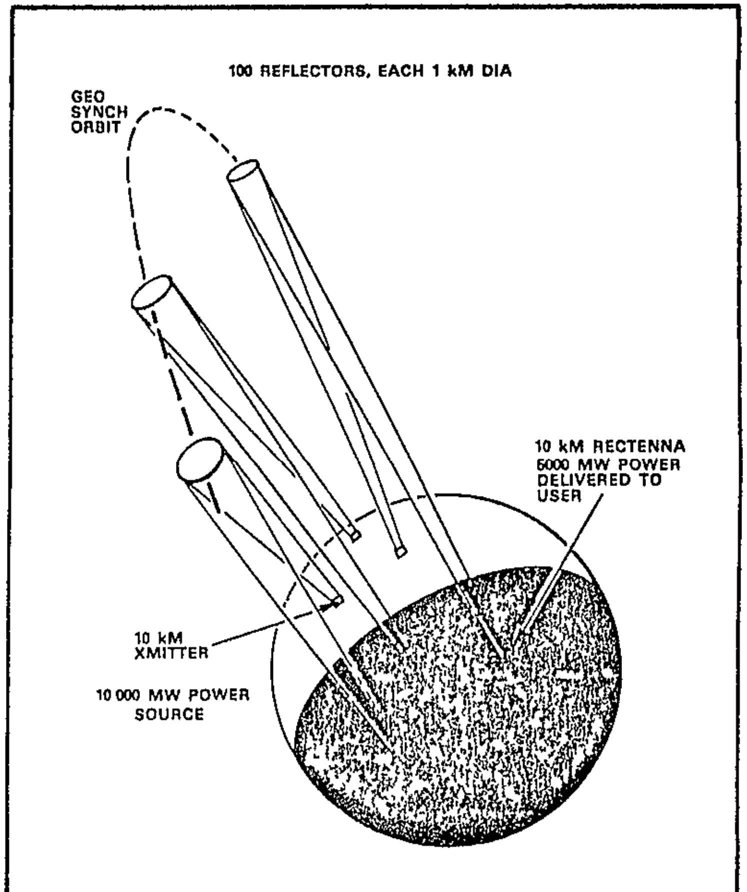
- **RATIONALE**
  Power should be generated in remote regions
  Sunny side of Earth can supply power to night side

- **CONCEPT DESCRIPTION**
  Source power is converted to a microwave beam, bounced off an orbiting reflector, and reconverted to DC at receiving antenna on ground.

- **CHARACTERISTICS**

• WEIGHT	600,000 lb
• SIZE	0.5-nmi dia
• RAW POWER	---
• ORBIT	Synch. Equat
• CONSTELLATION SIZE	100
• RISK CATEGORY	IV (High)
• TIME FRAME	1995
• IOC COST (Space only)	36 B

- **PERFORMANCE**
  5,000 megawatts delivered to each of 100 user areas
  53 percent overall DC-DC efficiency attained. Total energy is about 10 percent of U. S. consumption



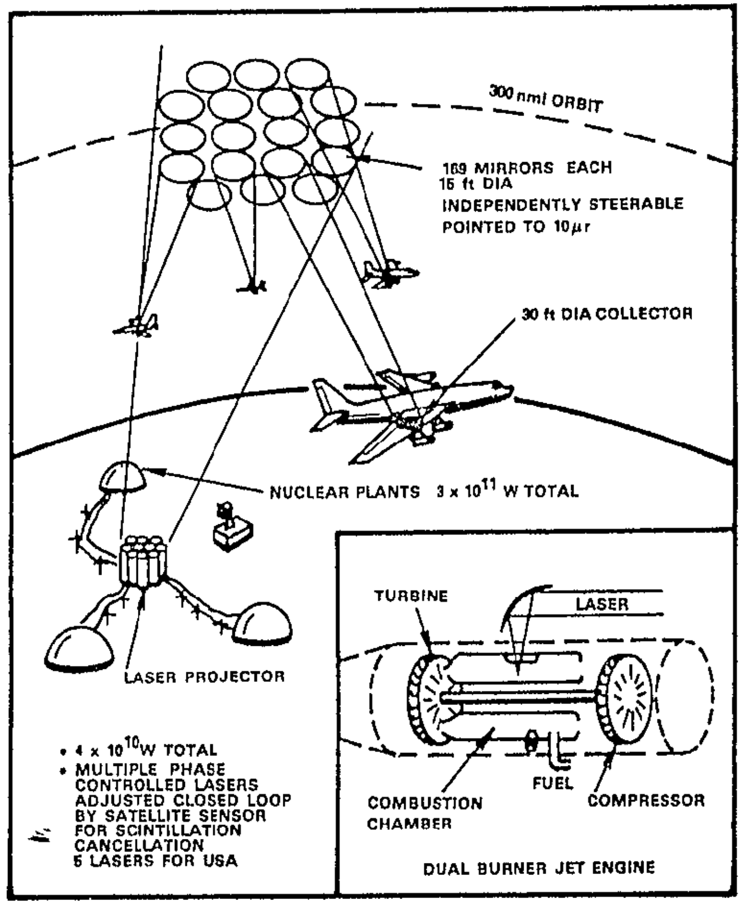
- **BUILDING BLOCK REQUIREMENTS**

• TRANSPORTATION	LLV and large tug or large SEPS
• ON-ORBIT OPERATIONS	Manned/automated servicing, assemble in orbit
• SUBSYSTEMS	Attitude control; structures, phase front control
• TECHNOLOGY	High efficiency, large, passive steerable phase front antenna; Ion thrusters
• OTHER	Ground-based elements

44

AIRCRAFT LASER BEAM POWERING (CS-5)

- **PURPOSE**
  To provide an alternative to oil as a source of energy for powering commercial transports
- **RATIONALE**
  Oil is a limited resource, becoming more expensive rapidly
- **CONCEPT DESCRIPTION**
  Jet turbines are operated by heating air with laser beams projected to each aircraft by multi-mirror satellites
  Laser on ground powered by nuclear reactors provides energy
- **CHARACTERISTICS**
  - WEIGHT — 2,000,000 lb
  - SIZE — 169 mirrors, each 15-ft dia
  - RAW POWER — ---
  - ORBIT — 300 nmi, 45^0 incl
  - CONSTELLATION SIZE — 200
  - RISK CATEGORY — IV (High)
  - TIME FRAME — 2000+
  - IOC COST (Space only) — 87 B
- **PERFORMANCE**
  2000 large jet aircraft powered continuously (30% duty cycle) at 10-50 MW/aircraft Break-even with oil operations at 50¢/gal.



- **BUILDING BLOCK REQUIREMENTS**
  - TRANSPORTATION — LLV and large SEPS
  - ON-ORBIT OPERATIONS — Manned or automated servicing unit; orbital assembly
  - SUBSYSTEMS — Attitude control; mirrors; processors; crosslink; thermal control
  - TECHNOLOGY — Large high temp mirrors; radiators; pointing and tracking sensors; LSI processor
  - OTHER — Ground high energy laser; atmospheric scintillation correction. Safety

ORIGINAL PAGE IS OF POOR QUALITY

45

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Electrophoresis

PRODUCT/SERVICE: Pure Biologicals (urokinase, blood cells, sperm, etc.)

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Use eletric field separation in static or continuous flow devices to produce cell based biologicals with very low impurity content. Micro-g makes cell surface charge dominate force. Possible applications in production of urokinase separation of blood cell, and sperm and cancer research

1) Urokinase
2) Pancreatic Cells
3) Pituitary Cells
4) Lymphocytes
5) Granulocytes
6) Macrophages
7) Bone Marrow
8) Sperm Cells

CHARACTERISTICS: Variable according to activity level

TECHNOLOGY:

IOC:

SITE:

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

MATERIALS

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Electronics

PRODUCT/SERVICE: Electronic devices

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

TRW has identified some immicible alloys as possible semiconductors. These immicibles can be more precisely controlled and manufactured in space.

Possible Applications: Better and more diversified products in calculators, watches, microelectronic circuits, that use less power or require less waste.

CHARACTERISTICS:

TECHNOLOGY:

IOC:

SITE:

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Single Crystal

PRODUCT/SERVICE: Large Single Crystals, Electronic

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Single Crystals grown in space have several advantages over ground base samples. They are free of container contamination and other consequences of gravity allowing them to be larger, cleaner, and a good deal more perfect. Single crystals can be made by vapor deposition, zone refining or other well known crystal growing techniques.

Possible Applications: Improved semiconductor devices specifically, better amplifiers, more precise calculators, smaller circuits, better diodes, LED's, smaller computers with larger capacities, better timers; maybe at a substantial power requirement reduction

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Crystals

PRODUCT/SERVICE: Large Crystal Rectifiers

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Large crystals of high homogeneity grown in micro-g capable of being applied to large scale power rectification.

Possible Application: Efficient AC-DC rectification for power transmission near corona limit

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Vibration isolation

PRODUCT/SERVICE: Imprinting of microcircuitry, small motor testing

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

High frequency components possible due to isolation from earth

CHARACTERISTICS:

TECHNOLOGY: State of the Art

SITE: LEO

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Metal Bubble

PRODUCT/SERVICE: Magnetic Memory Device

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

The elimination of large gravity effects allows manufacture of precise metal bubbles. These could be of very specific chemistry and controlled very tightly.

Possible Appliction: Use as data storage for faster data acquisition in computer memory devices

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Permanent Magnets

PRODUCT/SERVICE: Same As Above

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Process

Directional solidification, crucibleless environment

Uses:

(1) Seals for colostomy and ileostomy patients
(2) Elimination of scar tissue
(3) Motor size reduction (factor or 3-5 for consumer products)
(4) Weight of microwave power generators reduced by 60%

CHARACTERISTICS:

TECHNOLOGY: State of Art

SITE: LEO

TRANSPORTATION:

MASS: Capacity: 40×10^3 Kg/yr
Hardware: 10×10^3 Kg

IOC: 1985

DIMENSION: ~ 2x2x3 M

SUPPLIES:

POWER: 25 KW

GROWTH:

MANPOWER: ~10 Hrs/Wk

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Magnets

PRODUCT/SERVICE: Production of High Coercive Strength Magnets

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Controlled directional alignment in magnetic materials to increase field strength and lifetime in permanent magnets.

Possible Applications: Permanent magnet generators; more efficient electric motors, and microwave generators; magnetic bonding; improve solenoids; magnetic levitation

CHARACTERISTICS:

TECHNOLOGY: IOC:

SITE: DIMENSION:

TRANSPORTATION: SUPPLIES:

MASS: POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Superconductor

PRODUCT/SERVICE: Liquid H_2 Temperature Superconductor

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Complex intermetallic compounds and heterogeneous materials with precisely controlled internal structures have been theoretically identified to have superconducting properties at LH_2 temperatures is much more available than LHe and future supplies could be practically unlimited.

Possible Applications: Low loss power transmission; highly efficient electric motors; high field magnets (fusion); plasma propulsion

CHARACTERISTICS:

TECHNOLOGY:

IOC:

SITE:

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Liquid Immiscible Alloy

PRODUCT/SERVICE: Cold Cathodes

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Eutectic mixture of tungsten and nickel is etched to leave tungsten projection which are cold emmiters of electrons.

For TV sets there is no production cost advantage; however, there is power savings in operation and features such as instant-on could also be utilized in lasers.

CHARACTERISTICS:

TECHNOLOGY: State of the Art

SITE: LEO

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: AlSb Solar Cell

PRODUCT/SERVICE: Aluminum Antimonide (AlSB) Solar Cell

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Obtaining stoichiometric homegeneity in the AlSb compound will theoretically allow manufacture of a solar cell some 30-50% more efficient than silicon.

Possible Applications: Energy production on Earth, SSPS, satellites and spacecraft

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Vacuum

PRODUCT/SERVICE: Magnetron

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Present process requires large facility to evacuate before sealing these magnetrons.

Space processing would allow use of "cheap" high vacuum

CHARACTERISTICS:

TECHNOLOGY: State of the Art

SITE: LEO (behind shield)

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Metals

PRODUCT/SERVICE: Cermets

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Due to segregation and temperature limitations, production of cermets is confined to sintering. The use of space allow melting and dispersion allowing much more freedom in choice and treatment of cermet. Cermet could also then be cast or drawn to final form.

Possible Applications: Heating element, electrical contacts, cutting tools, abrasive tools, resistive metal, bushing, bearing, valves, rings

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Cast Structures

PRODUCT/SERVICE: High Reliability Castings

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Zero gravity and its associated reduction in convective effects minimize the voids and allow a wide measure of control over structure.

Possible Applications: Cast titanium structural parts, fine grained beryllium castings both in near completed shapes

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Energy

PRODUCT/SERVICE: Breeder Reactor Fuel

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

35 + immicible alloys containing Pu or U for use as breeder reactor fuel

Power production

CHARACTERISTICS:

TECHNOLOGY: 1985 for development

IOC:

SITE: LEO

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Lubricant

PRODUCT/SERVICE: Bearings, Self Lubricating

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

10 possible solid state binary alloy system showing liquid immicibility gap

Ref: TRW - Study on processing immicible materials in zero gravity

C. N. NAS 8-28267

CHARACTERISTICS:

TECHNOLOGY: State of the Art

IOC: 1980

SITE: LEO

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Ceramics

PRODUCT/SERVICE: Refractories

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Gravity effects quality and structure of ceramic materials. Lack of gravity combined with reduced contamination might allow a higher temperature inert refractory to be produced.

Possible Applications: Production of cermets, dispersion strengthened alloys, refractory alloys: high temperature engines, valves, molds

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Metal

PRODUCT/SERVICE: Electrical Steels

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

We can use space to make steels in thinner sheets at higher silicon contents in purer iron and therefore reduce the core losses in electromagnetic devices.

Possible Applications: Transformers, motors, generators, (possibly for lunar mining application)

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Metals

PRODUCT/SERVICE: Dispersion Strengthened Alloys

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Space low gravity allows more variety, more and better dispersions, with materials normally considered incompatible. These alloys exhibit high temperature, high strength, wear resistance and creep resistance.

Possible Applications: Turbine blades, electrical contacts, tools, cutting, impellers, springs, bearings, valves, fasteners, fittings, armour plate, gages, weld rods, thermoelectric and thermoionic devices (lead telluride)

CHARACTERISTICS:

TECHNOLOGY:

IOC:

SITE:

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE
INDUSTRIAL GOALS

KEYWORD: Jewelry

PRODUCT/SERVICE: Same As Above

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Four immiscible alloys identified which have the necessary value and could be processed more precisely in space. Also use of containerless shaping could give better finishes.

Possible Application: Jewelry, rings

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Metal

PRODUCT/SERVICE: Superplastic Materials

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Processing in space is conducive to production of metals with small equiaxial grains known as super plastic Materials

Possible Applications: Intricate punched parts and fittings use in racing applications, use with materials not normally drawn, such as, stainless steel, dispersion hardened steels, to make large numbers of small intricate fittings.

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Metals

PRODUCT/SERVICE: Refractory Metals

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Use of space would allow higher temperatures used without container contamination such that metals known as refractory metals could be alloyed and manipulated in greater freedom than ever before.

Possible Application: Tungsten x-ray targets, tungsten turbine blades, refractory cermets, valves, high temperature engines, cold emmiters

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Chemical Production

PRODUCT/SERVICE: Corrosion Resistant Electrode

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Super cooling metal ozide melts in abscence of nucleation sites and exposing to ionizing radiation an amorphous crystalline structure is produced. This done in space would lead to superior conducting glass at high temperature.

Possible Applications: Use in metal refining, chemical processes

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL-CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: High Purity

PRODUCT/SERVICE: Zirconium Cladding of Nuclear Fuels

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

High vacuum and containerless melting

Cladding of nuclear fuel elements (increased strength and reliability)

CHARACTERISTICS:

TECHNOLOGY: State of the Art

SITE: LEO

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Materials

PRODUCT/SERVICE: Composites

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Space has the unique ability to maintain liquid non-wetting stable composites due to high vacuum and negligible gravity. These composites could be cast drawn or otherwise processed by means impossible on earth.

Possible Applications: Light strong aerospace structural material, stiffness sensitive (golf clubs, fly rods, tennis racquets), exotic whisker metal, super high strength materials

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Zero-G

PRODUCT/SERVICE: Radiation Shielding

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Elimination of sedimentation

High Density particle in plastic matrix

CHARACTERISTICS:

TECHNOLOGY: State of the Art

SITE: LEO

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Contamination Free

PRODUCT/SERVICE: Carbon Filaments

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Increase size and uniformity due to zero-g and vacuum

Use to reinforce plastic

CHARACTERISTICS:

TECHNOLOGY: State of the Art

SITE: LEO

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Processing

PRODUCT/SERVICE: Brazing and Welding

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

On Skylab a brazing and a welding experiment was conducted. The results of these experiments demonstrated some advantages of space operation. The properties of high vacuum and reduced gravity allow larger molten zones, better alloy diffusion, less segregation and improved homogeneity.

Possible Applications: Welding of stainless steels, dispersion hardened steels, composites into turbines and other critical applications

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Chemical Industry

PRODUCT/SERVICE: Catalyst

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Many immicible systems that can be processed in space could have possible activity as catalyst. The use of foams would significantly increase surface area. Small galvanic couples might increase activity and resist passivity in catalysts. New combinations might lengthen life, highten performance and increase abrasion resistance.

Possible Applications: Coal conversion, petroleum refineries practically any area of chemical production

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Chemical Industry

PRODUCT/SERVICE: Metal Membrane

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Space allows the formation of metal membranes that are not possible in gravity.

Possible Applications: Chemical separations, isotope separation, solid state reactions, surface effect studies

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE
INDUSTRIAL GOALS

KEYWORD: Spheres

PRODUCT/SERVICE: Precision Powders

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

The use of space to produce spheres has been well demonstrated. It could be used to produce fine powders of well controlled size.

Possible Applications: Powder metallurgy, shot peening standards, used to clean ultra clean equipment such as for oxygen service, or medical use, used as extremely fine bearings

CHARACTERISTICS:

TECHNOLOGY:

IOC:

SITE:

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Manufacture

PRODUCT/SERVICE: Solid Extraction

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

We can make use of triple point in metals or sublimation to separate high purity fractions.

Possible Application: Distillation of isotopes, separation of ores

CHARACTERISTICS:

TECHNOLOGY:

IOC:

SITE:

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Radioisotopes

PRODUCT/SERVICE: Separation of Isotopes

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Zero-G would significantly reduce seperation cost, purity, elimination of hazards of processing

CHARACTERISTICS:

TECHNOLOGY: 1985

IOC:

SITE: LEO

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE
INDUSTRIAL GOALS

KEYWORD: Metals

PRODUCT/SERVICE: Rare Earth Metals

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

High vacuum and containerless melting allows a much greater purity and ease of handling of rare earths. These reactive metals have unique properties desirable in many fields limited by their purity and availability.

Possible Applications: Used in metal alloys for corrosion resistance, heat resistance and in glasses, refractories, ferromagnets, semiconductors, fungicides, as catalysts and others

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Process Control

PRODUCT/SERVICE: Sodium-Potassium Filled Thermostat

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Sodium-Potassium thermostats require vacuum of high pumping capacity in order to be processed.

Possible Applications: High temperature process control

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Fiber Optics

PRODUCT/SERVICE: IR Fiber Optics

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Continuous fibers of lithium fluoride (LiF) grown in a matrix of sodium chloride (NaCl) (ref. Skylab and ASTP); improved wide range transmittance with better image quality.

Potential use in law enforcement, security, process control, internal medicine, data transmission, etc.

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Zero-G

PRODUCT/SERVICE: Fiber Optic

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Chalcogenide glasses used in fiber optics improved by containerless melting and drawing

CHARACTERISTICS:

TECHNOLOGY: State of the Art

SITE: LEO

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Containerless Forming

PRODUCT/SERVICE: High Quality Lenses

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Elimination of surface polish roughness by use of containerless shaping; proper cooling to obtain homogeneity.

1) High Resolution Cameras
2) Specialized Microscopy
3)

CHARACTERISTICS:

TECHNOLOGY: State of the Art

IOC:

SITE: LEO

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Vibration

PRODUCT/SERVICE: Optical Filters

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Higher precision due to absence of earth vibration and gravity effects

1) Narrow Pass (wavelength (single)
2) Selected Pass (multiple wavelength)
3)

CHARACTERISTICS:

TECHNOLOGY: State of the Art

SITE: LEO

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Zero-G and Contamination Free

PRODUCT/SERVICE: Coating of Optical Reflectors

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Aluminized optical reflectors improved quality in Zero-G and vacuum of space

CHARACTERISTICS:

TECHNOLOGY: State of the Art

IOC:

SITE: LEO

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Glass

PRODUCT/SERVICE: Electrically Conductive Glass

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Transparent glass properly mixed with conductive materials may have good electrical conductivity.

Possible Applications: Solar cell cover if wavelength and intensity transmittance right; simple security system in buildings; self defrosting car windows without internal wires

CHARACTERISTICS:

TECHNOLOGY:

IOC:

SITE:

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Contamination Free

PRODUCT/SERVICE: Glasses

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Removal of Boron Oxide
Ability to cool with nucleation will allow glasses to be made that are not now possible. They would have different
- Transmittance
- Damage Thresholds
- Strength
- Indexes

uses envelopes for lamps
optical quality glass
lasers

CHARACTERISTICS:

TECHNOLOGY: Developed

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

YWD

NOV 1 2 1976

POTENTIAL PRODUCTS FROM SPACE INDUSTRIALIZATION

Self-lubricating high-temperature sleeve bearing. There are many self-lubricating bearings available today. A common one is made of stainless steel fiber metal impregnated with lead. When the bearing gets hot enough to melt the lead, the molten lead in the fiber metal matrix acts as a lubricant. However, the tensile strength of fiber metals decrease as a function of their density. By impregnating a tungsten whisker matrix with a lower melting point metal or alloy, or with an alloy wherein only one component undergoes phase change to liquid state at bearing operating temperatures, we could create a high-strength high-temperature sleeve bearing for such applications as gas turbines, steam turbines, power plant turbines, etc. Would also make a damned fine railway journal bearing because of its ability to sustain high transverse loads.

Low-light-level TV camera or microminiature TV camera. If a perfect semiconductor crystal could be manufactured in zero-g, the density of microelectronic devices that could be put on a single chip could be increased by a factor of 100. Thus, about 750,000 microelectronic components could be incorporated on a 1-inch-diameter disc. If these are photocathodes, the disc would be the heart of a low-light-level or very small TV camera. Smaller TV cameras will always find a market in both industry and entertainment. If cost can be reduced because of a reduction in chip rejects caused by crystal imperfections, price of TV cameras could also come down, leading to a broader market, even in domestic home use.

High-quality gallium arsenide crystals. Gallium arsenide is a commonly-used material in LED's, Gunn Effect diodes for microwave use, etc. Reject rate is high because of the inability to grow perfect GaAs crystals in one-g. In zero-g, GaAs crystals could be grown to large, perfect crystals from the metallic solution, which is a cheaper, more reliable way to do it with lower reject rate. This can lead to cost reductions in any device presently using LED's, including digital counters and presentations of all sorts.

Improved germanium telluride and germanium selenide crystals. Both GeTe and GaSe are widely used semiconductor materials, but are hard to grow without high reject rates in one-g because convection causes fluctuation in temperature of the crystals during growth by vapor phase deposition. Increase in perfection of crystals of these substances should lead to lower reject rates of semicons made with them and thus reduce the price of semicons and IC devices.

New semiconductor material from Gold+Germanium. Gold and Germanium are immiscible metals. But a homogenous mix can be achieved by melting, mixing, and solidifying Au and Ge in zero-g. Skylab experiments have shown some interesting semiconductor properties of this mix. A whole new area of high-current semicons could result, leading to improved products in the high-current diode area, leading in turn to practicality of DC power transmission systems using existing transmission lines.

High-temperature superconductor. Skylab experiments with the immiscible metals lead, indium, and tin produced an immiscible alloy with a transition temperature of 9.2K. Further work in this area may lead to a superconductor at liquid hydrogen temperatures. Some data indicates the transition temperature is increased in a magnetic field. This would lead to high-efficiency transformers and other energy-saving electric power transmission equipment.

Improved germanium semicons for microelectronics. Size, number of elements, and reject rate of microelectronic chips, PROMS, and other IC devices is lkmited by imperfections in germanium crystals and microstructures formed in one-g. Both the price, size, complexity, an acceptance rate of microelectronic devices could be inproved by zero-g processing.

Improved whisker-reinforced composite materials. Dispersions of whiskers of silicon carbide in metals can be improved by zero-g processing, leading to super-light, high-strength, and high-temperature composites of reduced price and higher production. These would have uses in aircraft, automobiles, trains and other transportation devices where strength-to-weight ratio is important for performance and efficiency. A number of large, heavy, unwieldy industrial devices could also be lightened and strengthened. For example, ~~press~~ rolls in a paper machine could be lightened and strengthened, thus making it quicker and easier to cantilever them to change the Fourdrienier wire, press felt, or drier felts. The high temperature characteristics of possible compotsites also would permit their use as rolls in steel sheet and bar mills. They would also permit the redesign of many industrial components where weight and strength are important and where a reduction in weight with no reduction in strength could lead to savings in material costs in the machine itself.

Uniform semicon materials. Any improvement in the production of semicon materials such as germanium, gallium arsenide, indium antimonide, and gallium antimonide by zero-g processing to eliminate crystal flaws and/or homogeneity would lead to improved performance and lowered reject rate of electronic components using these materials.

Improved capacitors and supercaps. Lamillar eutectics can be grown or formed in zero-g without the dislocations in the plate-like structures caused by forming in one-g. Development of lamillar eutectics consisting of a conductor and a semiconductor or ilsulator in zero-g could lead to improved capacitors for microelectronics or supercapaitors (capacitors of very small physical size and very high capacitance) for use in microelectronics chips, discrete electronics equipment, energy storage, and power generation and transmission.

Directional magnetic materials. Certain lamillar eutectics can be formed in zero-g that will incorporate aligned magnetic materials in the lamillar structure. This will create magnets of more uniform field orientation, greater field strength, and more uniform flux. They would be useful in making smaller and more efficient electric motors for home appliances, for electric autos, and for industrial uses. They would also be useful in improved loudspeakers of lighter weight. They would find application in mag amp equipment for industrial controls of lighter weight and improved long-term performance as well as in electric control equipment such as relays and circuit breakers.

Eutectic wave guides. The lamillar structure of some eutectics leads to the speculative possibility of being able to form such eutectics of such materials that would form very high frequency wave guides, perhaps by using a semicon inside an insulator martix or by etching the lamillar material out of the eutectic to create lenticular voids in the material that would act as waveguides. This would permit further development of electronic equipment in the gigahertz frequency spectrum for industrial instrumentation and control, as one example.

Improved fiber optics using eutectics. Both halide eutectics and lamillar eutectics show promise of being developed into improved fiber optics equipment. Fiber optics made from such eutectics would be characterized by more compact size for a given number of optic fibers. Initially, length of such fiber optics would be two to three centimeters, which would permit their use in imaging equipment, lenses, etc. Primary characteristic would be reduced price and easier manufacture.

Standardized micropore filters. Micropore filters made from posdered metals or fiber metals are characterized by the gaussian distribution of their pore sizes. By melting metallic grids in zero-g, micropore filters of more standardized pore opening size would be created. These would have application in biological and chemical work. To some extent, they would also be useful as libricant-impregnated bearing materials.

Production of pure metals by outgassing. Outgassing has often been presented as a problem area of space processing. However, by turning it around and making it a process itself, it leads to the possibility of producing super-pure materials by permitting them to deliberately out-gas in the vaccum environment of space. The combination of containerless melting and vacuum outgassing permits such super-pure metals as beryllium which is brittle and hard in its unpure state but ductile and machinable in its pure state. Beryllium is an excellent neutron reflector, and the application of super-pure beryllium in the nuclear industry alone should be looked into. The combination of its nuclear properties plus its physical properties may make it more useful in areas where it currently cannot be used because of poor physical properties.

New catalysts. Current catalysis theory indicates that catalysis probably occurs only at the surface of the cataylist material. Improved cataylists can be made by increasing the surface area through controlled crystallization, permitting the long-growth of dendrites in zero-g. This could lead to new catalysts as well as a possible improvement of some existing catalysts that are grown or growable in the crystalline state.

Tungsten-copper composite. The uniform mixture of tungsten and copper attainable in zero-g leads to the possibility of producing this material for wear-resistant high-temperature applications in electric equipment such as high-power circuit breakers, high-current relay points, and other electrical switching devices. This means longer life, which means shorter down-time for replacement, lower inventory levels for on-hand replacement devices, and therefore lower cost and investment with less money tied up in investment in equipment.

Improved infra-red optics. Uniform and homogenous chalcogenide glasses produced in large qualities and size in zero-g melts would permit improved and cheaper infra-red optics. This in turn may lead to such products as domestically-available night vision equipment for sercurity, travel, transportation devices such as autos; industrial instrumentation such as vapor quantity measurement in processes; police equipment; fire detection equipment for cities, buildings, etc.

"Space wood." High-temperature, high-strength, light-weight structural material made of foamed metal reincorced with aligned metallic whiskers. Architectural uses. Utility in any transportation device where light weight and tensor structural strength would be important. "Metallic balsawood" in concept.

Structural insulation. A combination of an organic foamed plastic such as polyeurethane or polystyrene with oriented whisker reinforcement to produce a thermal insulator with tensor structural characteristics. This would have application in hydrogen-powered aircraft and automobiles, space craft, large refrigeration equipment, railroad reefer cars, railroad tank cars for LNG, ocean-going LNG ships. Most thermal insultation equipment today is non-structural and must be made into a sandwich with a structural material in order to bear loads in compression or tension.

Tensor electrical conductor. By combining copper with oriented whisker reinforcement material in a wire, electrical transmission lines could be made larger without the need for additional supporting towers, thus permitting up-grading of existing transmission lines to higher load-carrying capabilities without adding towers. Or new transmission lines coule be built using fewer supporting towers. Such tensor wire would also be useful in making stronger cables of smaller size for guys, supports, hoists, lifts, cranes, etc. (In large cranes and long elevator lifts, the weight of the cable itself becomes a major load factor.)

Ultimate tensile microwire. Continuous whisker material grown in space with tensile strength approaching or exceeding ultimate strengths and in lengths of a meter or more. Replaces all saws and sawing devices, cutting devices, and slicing devices for materials of lesser hardness than the wire. Makes possible extremely strong, lightweight whisker-wrapped pressure vessels.

"Heat wires." Thermally tensor wires or rods made from whisker materials and coated with thermal insulator material of much lower tensile strength. Conducts heat along the whisker material with little radiation off the wire or rod. Has higher strength than simple wire.

Ultra-hard materials. Production of high-temperature carbides and nitrides by containerless melting in vacuum conditions, causing vacuum purification, and controlled cooling to produce uniform crystalline structure. Has potential of possibly being nearly as hard (or perhaps as hard) as diamond because of the regular crystal matrix. Would have superior electrical conduction properties and may even act as a superconductor with high transition point. Using acoustic suspension and shaping by standing waves while cooling, could be formed into wire dies and other shapes.

Amorphous semiconductors. Ovshinski's Dream come true! Production of amorphous semiconductor materials could be possible in zero-g because of the uniformity and lack of segrgation possible. This would lead to amorphous semiconductors which in turn might lead to picture-wall TV screens, for example.

Space-made glass products: Because of the fact that glass produced in zero-g is more homogeneous than that produced in one-g, and because of new types of glass that can be produced in orbit, the following products would be affected, and the following products could be produced with performance characteristics better than one-g glass. (No implication is made as to whether or not they would be economically competetive with one-g glass.) Host materials for lasers; raw materials for lens coatings; multi-element lenses for high numerical aperture systems such as microscope objectives, low light level lenses, and long focal-length lenses; multi-element lenses with high n for anastigmat photo objectives, aplanats, and lower curvature lenses for zoom, spectrometers, monochromators, polarizing microscopes, and high speed large lenses; high numerical aperture systems including oil-immersion microscope objectives and fiber optics bundles.

Improved high-strength castings: One-g castings of metal show a definite change in grain size between the wall of the mold and the center of the casting, the harder metal being on the outside of the casting because of smaller grain size. Uniform cooling of castings in zero-g in the absence of convection cells within the casting would result in castings of more homogeneous internal structure, thereby permitting castings made in zero-g to be smaller and lighter than their terrestrial analogs of equal strength. Although such space castings will probably first be used in space-made spacecraft and in large space structures from lunar and planetoidal materials, their use would eventually trickle down to earth. Thus, castings made in space could probably compete with forgings made on earth because space castings could have complex shapes and surfaces.

Immiscible alloys, general: It appears that immiscible alloys that cannot be made on earth because of density segregation during cooling and that can be made in space in the absence of g-forces to cause density separation and convetive cooling interally would have applications to the following general product areas and systems: Fine particle superconductors; breeder reactor fuels; nuclear reactor structural materials; nuclear reactor control rods; bearing alloys; jewelry, solid lubricants; superplastic materials; and magnetic detectors of enhanced sensitivity. The list of possible products, markets, etc. that are touched by this one area alone would require a complete one-year+ study.

Aluminum antimodide solar cells. Possibility of alloying aluminum antimodide in zero-g demonstrated in ASTP indicates possible new type of solar cell with higher conversion efficiency.

Urokinase produced by electrophoresis. A better way to produce urokinase. The only way to produce pure urokinase with a higher yield from human kidney cells and urine. Used to treat cancer, leukemia, cardiovascular diseases.

[redacted]

High-cohesive strength permanent magnets. On earth, permanent magnets are usually formed by sintering which destroys and/or degrades their properties by oxidation. There are also many steps involved. They could be made in a single step in zero-g with higher density and better magnetic properties because of the absence of segregation. Possible uses include levitators for high-speed ground transportation systems and devices, gyros, and bearings for energy storage flywheels.

Monolayer crystals. The first of these has just been formed by Bell Labs with alternate one-atom-thick layers of GaAs and AlAs. When pumped, it emits polarized laser light. It may be the first of a family of layered crystals. These can probably be made in space using free-atom chemistry techniques.

Metallo-organic polymers. Utilizing the vacuum and zero-g properties of space, it will be possible to make in great quantities such exotic polymers as platinum-propylene. The so-called "noble metals" can be made to combine with introverted organic molecules to produce new plastic-like materials with presently k unknown properties. Among these properties may be extreme chemical corrosion resistance, even better than that of teflon; high-tempurature characteristics in molded thermoplastic and thermosetting plastic materials; unsuspected catalysis effects. This is far-out stuff. It might even be possible to make an internal combustion engine block by injection-molded metallo-organic polymers. A new technology.

Improved dental materials. Dental fillings are normally made of an amalgam [redacted] of silver and mercury. This material has a higher heat transmission factor than tooth enamel or pulp, as well as a different coefficient of thermal expansion, leading to a useful lifetime in a tooth of from 10 to 15 years. A hard, non-toxic, non-corrosive, high-strength composite is required to replace the amalgam. A thermo-setting fiber-re-inforced noble metal polymer might be an answer. Such a material could be made only in space. The market is small (150,000 USA dentists) but everyone has teeth that need plugging. Material would cost more than amalgam, but would offer longer life with fewer visits to the dentist. The suggested material may not be the most practical one, but further research needs to be devoted in this area.

PEOPLE

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Tourism

PRODUCT/SERVICE: Sightseeing

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Short duration flights into space for the sightseeing spectical and to experience weightlessness.

Near-Term: Perhaps on an as-space-available basis ($\sim 10^2$ people/year)

Mid-Term: Using personnel transporter 10^2 people/flight @ \$$10^4$-$10^5$ each

Far-Term: Probably in connection with hotel facilities 10^4-10^5 people/year

CHARACTERISTICS:

TECHNOLOGY: Shuttle to Advanced Vehicles

SITE: LEO

TRANSPORTATION:

MASS: -

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH: Moderate
($\gtrsim 10^6$ people/yr.)
(\$$10^3$ each)
($\gtrsim$ \$$10^9$/year.)

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Tourism

PRODUCT/SERVICE: Meditation Facilities

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

The silence, peace and lofty viewpoint of a space mediation facility would be hard to compare. Perhaps furnished as one or two person "pod" lifesupport systems to minimize interaction with others via structural vibrations. This could serve as the basis of a spiritual movement. Isolation for internal awareness and sleep inhancement could also be possible.

CHARACTERISTICS:

TECHNOLOGY:

SITE: LEO

TRANSPORTATION:

MASS:

IOC: Mid to Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH: Low
($\gtrsim 10^5$ people/year)
($\sim \$10^3$/person)
($\sim \$10^8$/year)

MANPOWER:

COSTS: (see Hotel)

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Medical

PRODUCT/SERVICE: Infectious Disease Isolation

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

The toally artificial environment that must be maintained to support man-in-space suggests that a space habitat would be ideal for infectious disease isolation. Perhaps "flip-top" rooms to permit sterilzation by direct exposure to sunlight and vacuum. In addition, total isolation is possible without possibility of spreading to the Earth.

CHARACTERISTICS:

TECHNOLOGY:

SITE: LEO

TRANSPORTATION:

MASS:

IOC: Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH: Low

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

People
Medical
Isolation

POTENTIAL CANDIDATE SPACE
INDUSTRIAL GOALS

KEYWORD: Elimination of exogenous forces

PRODUCT/SERVICE: Biological Research

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Utilization of biorythms

(possibly treatment for diseases)

CHARACTERISTICS:

TECHNOLOGY: State of the Art

SITE: LEO

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

People
Medical
Treatment

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Medical

PRODUCT/SERVICE: Low Stress Environments

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

In reduced g or zero g, recuperation from many medical ailment, may be easier or even faster. Specific atmospheres are also easily obtained to increase the oxygen content and/or reduce the total pressure or provide a totally sterile environment. Recuperation from major operations, heart or respiratory difficulties are prime candidates.

CHARACTERISTICS:

TECHNOLOGY:

IOC: Mid to Far-Term

SITE:

DIMENSION:

TRANSPORTATION: Low acceleration manned transport E to LEO RT

SUPPLIES:

MASS:

POWER:

GROWTH: Moderate
(~10^2* affluent population)
(major operations/year)
(at ~ \$$10^3$-$10^4$ each)
(~\$$10^{10}$/yr. with 1/3)
(recuperation costs)
(~\$$10^9$/yr.)

MANPOWER:

COSTS: (see Hotel)

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Medical

PRODUCT/SERVICE: Burn Treatment

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Severe burn victims need to be isolated from contact from objects (floated) and from infection. The zero g and controlled (sterilized) environments seem ideal for a LEO facility if transportation (perhaps emersed in oil) is feasible.

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION: Problem

MASS:

IOC: Mid to Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE
INDUSTRIAL GOALS

KEYWORD: Medical

PRODUCT/SERVICE: Handicap Augmentation

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

People with handicaps such as leg amputees, spinal problems, or muscular problems could have increased comfort and productivity in zero or reduced g environments.

CHARACTERISTICS:

TECHNOLOGY:

SITE: LEO, HED

TRANSPORTATION:

MASS:

IOC: Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS: (see Colony)

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

People
Entertainment
Objects

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Arts

PRODUCT/SERVICE: Artwork Made in Space

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Art objects made in space using micro g, insolation, view or vacuum. Example:

- o Early; molten glass sphere inverse sculptured with microbubbles either injected or formed by focused energy.
- o Midterm; major new sculpturing techniques will be possible in space where major stresses are removed, i.e., large, light etherial objects.
- o Far-term; sculpturing features on the moon.

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC: Early to Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH: Low (Space paintings could initially sell for $\$10^4$)

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Arts

PRODUCT/SERVICE: Reproductions Made From Space

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Use in space art for making masters from which many copies can be made later on Earth as a means for getting early timing for space art. Examples include lithography plates, holograms of space sculptures, sculpture molds, etc.

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC: Early to Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH: Low

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

People
Entertainment
Objects

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Arts

PRODUCT/SERVICE: Ideas and Topics from Space

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

The new environments of space furnish the basis for new art ideas and topics. Already there is SF art, art by astronauts, and pictures of space, the Earth, the moon, mars, etc.

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC: Early to Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH: Low

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Entertainment (Spectator)

PRODUCT/SERVICE: Sports

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Near-Term: Special 2 man competition in habitable volume $\sim 10^3 - 10^4 m^3$
ex: personal combat, dodge ball, "water ball" - each using zero g in LEO for minimal orbital time.

Mid-Term: Small team competition in habitable volume $\sim 10^5 - 10^7 m^3$
ex. races and timed events, basketball type accuracy sports - each using zero g in LEO during moderate orbital time.

Far-Term: Any sports supported by space population, variable g, large volume and possibly vacuum.

CHARACTERISTICS: see above

TECHNOLOGY:

IOC:

SITE:

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH: Low (to $\sim\$10^9$/yr.) (only partly attributable to space.)

MANPOWER:

COSTS: Mainly transportation and arena which may be spinoffs of other activities.

ESTABLISHMENT:

OPERATIONS:

PRODUCT: Sports spectaculars gross \$5-10M

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Entertainment (Spectator)

PRODUCT/SERVICE: Movie/TV ("Special Effects")

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Use space setting for realistic space special effects.

Near-Term: This will probably be with limited crews (3-6) and equipment (.1-1T) in LEO for short duration.

Mid-Term. Use of the space base and other in situ facilities and crews as well as filming/acting staff of 10-100.

Far-Term: Could see full scale productions in space, on the moon or near astroids.

CHARACTERISTICS: see above

TECHNOLOGY:

IOC:

SITE:

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH: Low (to ~$\$10^8$/year)

MANPOWER:

COSTS: Major movies cost $10-25M

ESTABLISHMENT:

OPERATIONS:

PRODUCT: Major movies gross $20-50M

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Entertainment (Spectator)

PRODUCT/SERVICE: Dance

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

A new art form may be partial or zero g ballet or "modern" dance. The possibilities for enhanced grace, slow motion and full 3D should provide major interest in space dance. Ballet is based on speed, balance, and leaps...adjustment would be necessary.

CHARACTERISTICS:

TECHNOLOGY:

IOC: Mid to Far-Term

SITE:

DIMENSION:

TRANSPORTATION:

SUPPLIES:

MASS:

POWER:

GROWTH: Very low (to ~$$10^7$/year)

MANPOWER:

COSTS: Major ballet productions cost ~$1/2M

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Tourism

PRODUCT/SERVICE: Amusement Park

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Recreation, sports and amusement facility in conjunction with sightseeing and hotel facilities. Will provide zero g, variable g, coriolis force, EVA, observations, etc. Many normal physical activities will take on new dimensions in zero g such as dancing, swimming, sexual congress, sleeping, etc. Should be synergistic with space hotel.

Future versions could be in HEO and LSU but initially in LEO.

CHARACTERISTICS:

TECHNOLOGY:

SITE: LEO, HSO, LSU

TRANSPORTATION:

MASS:

IOC: Mid to Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH: Low
($\gtrsim 10^6$ people/yr)
($\sim \$10^2$ each)
($\gtrsim \$10^8$/year)

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Tourism

PRODUCT/SERVICE: Hotel

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Temporary lodging in space for tourists.

Mid-Term: $\sim 10^2$ people habitat ($\sim$10 staff) in LEO minimal quarters, mainly rooms and "free-fall hall" and observational facilities.

Far-Term: $\sim 10^3$-10^4 people habitats in LEO, HEO, LSU

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC:

DIMENSION:

SUPPLIES:

POWER:

GROWTH: Moderate
($\gtrsim 10^6$ people/yr.)
($\sim \$10^3$ each)
($\gtrsim \$10^9$/year)

MANPOWER:

COSTS:

ESTABLISHMENT: Based on T/person for habitat

OPERATIONS: Based on support in \$/person-day.

PRODUCT:

People
Recreation
Cabin

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Tourism

PRODUCT/SERVICE: Space Cabin

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Small one family habitats in LEO and later even HEO and LSU. For the person wanting "to get away from it all". A logical extension beyond the beach and mountain cabin.

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC: Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS: (see Hotel)

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

People
Education
In-Space

KEYWORD: Education

PRODUCT/SERVICE: In-Space

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Classes or instruction in space allows utilization of "natural" environment for teaching science or global subjects (geography, world wide perspective). Ex.: sciences could utilize variable g and vacuum for teching kinetics, actual student participation to learn Newton's laws.

1) Broadcast to Earth
2) In-Space Education
3) Combination of 1) & 2)

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION: Very inexpensive human transportation.

MASS:

IOC: Mid to Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH: Moderate

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Security

PRODUCT/SERVICE: Maximum Security Prisons

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

A maximum security prison in orbit, on the moon or in an astroid. Similar to the early use of Australia. This penal colony could require no guards and only one-way ships.

CHARACTERISTICS:

TECHNOLOGY: Colony level· closed ecology, etc.

IOC: Far Term

SITE: Any

DIMENSION: Large

TRANSPORTATION: One way, expendable?

SUPPLIES: Minimal

MASS: Large

POWER:

GROWTH: Low

MANPOWER:

COSTS: After colonization efforts, ~$$10^{10}$

ESTABLISHMENT:

OPERATIONS: ~$$10^7$–$10^8$

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

KEYWORD: Experimentation

PRODUCT/SERVICE: Social Alternative/Life Boat

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

In the far term, space colonies could provide test beds for social experimentation leading to new alternatives. These will also provide mankind with a lifeboat in case of disaster on Earth.

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC: Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

People Support
Ecological Isolation

KEYWORD: Experimentation

PRODUCT/SERVICE: Ecology Labs

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

By setting up environments isolated from the biosphere alternative ecological systems can be tested without contamination.

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC: Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH:

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

POTENTIAL CANDIDATE SPACE INDUSTRIAL GOALS

People Support
Ecological & Social Isolation

KEYWORD: Experimentation

PRODUCT/SERVICE: Potentially Hazardous Developments

DESCRIPTION (INCL. PROCESS & SPACE USAGE):

Potentially hazardous developments and experiments (e.g., genetic engineering-recombinant DNA, CBW etc.) should be isolated from the biosphere, a space lab would seem to be ideal.

CHARACTERISTICS:

TECHNOLOGY:

SITE:

TRANSPORTATION:

MASS:

IOC: Near to Far-Term

DIMENSION:

SUPPLIES:

POWER:

GROWTH: Low

MANPOWER:

COSTS:

ESTABLISHMENT:

OPERATIONS:

PRODUCT:

APPENDIX D

INTERNATIONAL LAW AND SPACE INDUSTRIALIZATION

INTERNATIONAL LAW

AND

SPACE INDUSTRIALIZATION

By

Delbert D. Smith

RI-SI/1/B/8-29-77

TABLE OF CONTENTS

MEMORANDUM

TO: Rockwell International, Space Division

SUBJECT: International Law and Space Industrialization

The present memorandum,* which is designed to explore the impact of international space law upon the future industrialization of outer space, is divided into four main segments. First, the concept of space industrialization is outlined. Second, existing international agreements affecting the utilization and development of outer space are examined in terms of their respective influences on various types of space industrialization. Third, current negotiations relating to the formulation of international guidelines for the use of outer space for particular purposes, including direct television broadcasting, satellite remote sensing, and exploitation of lunar resources, are assessed both as a means of projecting possible international legal regimes in those particular areas, and for identifying trends which could affect other types of space utilization. Finally, recommendations for actions designed to facilitate space industrialization are discussed.

---

*The views and conclusions contained in this memorandum are those of the author and do not necessarily reflect or represent the views or policies, either expressed or implied, of any organization, agency, or group.

PART I: THE CONCEPT OF SPACE INDUSTRIALIZATION

For purposes of the present memorandum, the concept of space industrialization is used in a broad sense to encompass an extensive array of possible uses of outer space. Five main categories of activities are encompassed.

A. Communications Services

The success of recent communications technology applications programs conducted by NASA[1] and the prospects for resumption of NASA communication satellite experimentation indicate that technical and economic feasibility for a large number of innovative communications services is likely to be achieved in the near future. Among the communications activities which are projected for near- or middle-term satellite implementation are:

1. teleconferencing;
2. direct television broadcasting;
3. electronic mail;
4. electronic funds transfer;
5. improved data communications;
6. business and home communications systems incorporating computers and small-scale receiving terminals;
7. improved mobile communications for personal and vehicular use;
8. medical information services, including telediagnosis, patient monitoring and access to medical records;
9. improved disaster warning services based on enhanced remote sensing and meteorological applications; and
10. search and rescue communications.

Although not exhaustive, this listing indicates the scope of future possibilities for the utilization of outer space, and particularly the geostationary orbit,[2] for communications.

B. <u>Remote Sensing Services</u>

Public and private experimentation in the satellite remote sensing area centering around NASA's Landsat Program has demonstrated the feasibility of using satellites for the acquisition of data relating to the earth and its environment. The breadth of experimental activities has facilitated identification of an extensive listing of potential applications and services.[3] Set forth below is a listing of a number of the general categories into which these applications may be divided:

1. Mineral resources monitoring;
2. Ocean resources management, including living and non-living resources;
3. Crop surveys, including insert and disease monitoring and yield projections;
4. Land use management;
5. Population surveys;
6. Monitoring of pollution in the atmosphere, rivers and streams and oceans;
7. Weather and climate forecasting; and
8. Non-meteorological disaster forecasting.

C. Satellite Power Systems

The 1973 embargo on the export of petroleum products to certain oil-consuming countries imposed by members of the Organization of Petroleum Exporting Countries (OPEC) and subsequent events, including energy shortages, increasing energy costs and their economic, social and foreign policy implications, have promoted the search for cost-effective, alternative energy sources. One possibility is the establishment of generating facilities in orbit which would relay resultant energy to the earth's surface using a microwave or laser transmission system. Three main alternative methods of power generation are under consideration solar energy, nuclear fission and nuclear fusion. Relay of electrical power generated either in space or on the earth's surface via satellite to secondary receivers constitutes another option for the industrialization of space.

D. Space Manufacturing

A number of experiments relating to physical and chemical properties of matter in outer space conducted during NASA's Skylab program indicate that certain unique characteristics of outer space, including weightless, vacuum and extreme temperature differentials, may permit the manufacture of products which either could not be produced on the earth or would be of significantly inferior quality. A number of specific benefits have been identified, including:

1. production of superior electronic products, especially semiconductor crystals;
2. pure vaccines and other pharmacentical products,
3. improved laser glass and optics manufacturing;
4. production of alloys of metals which are otherwise immiscible in their respective liquid states;
5. production of superconductors,
6. assembly and maintenance of large space structures, including space stations and vehicles.[4]

E. Deep Space Operations

In contrast to the operations described above which would be most likely to occur at altitudes above the earth between 100 and 22,300 miles, a number of activities relating to the development of outer space could be undertaken advantageously beyond that limit. Perhaps most important of these is the mining of minerals on the moon and other celestial bodies.

PART II: APPLICABLE INTERNATIONAL AGREEMENTS

International space law applicable to the space industrialization activities described in Part I is embodied in a series of treaties and conventions adopted primarily under the auspices of the United Nations. The fundamental Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies[1] resulted from initiatives within the United Nations and after several years of negotiation was signed in 1967. In subsequent years, other treaties were negotiated to elaborate the basic principles defined in the 1967 treaty. Perhaps most important from the perspective of space industrialization is the Convention on International Liability for Damage Caused by Space Objects, which entered into force for the United States in 1973.[2]

I. TREATY ON PRINCIPLES GOVERNING THE ACTIVITIES OF STATES IN THE EXPLORATION AND USE OF OUTER SPACE, INCLUDING THE MOON AND OTHER CELESTIAL BODIES

The 1967 Outer Space Treaty provides the foundation for the legal framework for all activities beyond the upper limits of national airspace jurisdiction. Consequently, its provisions are relevant to the consideration of all four major categories of space industrialization. Particular consideration should be given to the provisions governing·

1. permissible uses of outer space (Articles I, IV and IX),

2. non-appropriation of outer space (Article II),
3. applicability of international law (Article III);
4. military uses of outer space (Article IV);
5. responsibility of states for the acts of nationals in space (Article VI);
6. international liability for damage caused in space (Article VII);
7. the exercise of national jurisdiction in outer space (Article VIII); and
8. relations between states relating to their respective space activities (Article IX).

A. Article I

Article I, which establishes the most basic principles governing activities in outer space, provides:

> The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.
>
> Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.
>
> There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international co-operation in such investigation.

1. Article I(1): The "Common Interests" Clause

Paragraph 1 raises two main issues. first, whether this provision constitutes a binding contractual obligation or is

merely declaratory of general objectives, and second, regarding the meaning of the phrase "for the benefit and in the interests of all countries." Related to the former is the question whether the provision is self-executing. Some authorities argue that although the so-called "common interests" clause of Paragraph 1 embodies one of the most fundamental principles upon which the outer space regime is founded, its breadth precludes direct application. Consequently, other, more limited expressions of international consensus are required to give this provision enforceable form. Under that approach, pending agreement on specific operative principles elaborating the fundamental policy of Article I(1), any use of outer space would be permitted under Article I(2), provided it is peaceful in nature.[1]

A contrary conclusion is reached by a number of other authorities who take the position that the language of Article I(1) is binding upon the signatories, as is any provision of an international treaty. Two main reasons are advanced to support this proposition. First, during consideration of the text of the provision in the fifth session of the Legal Sub-Committee of the Committee on the Peaceful Uses of Outer Space (CPUOS), a proposal to delete the phrase "for the benefit and in the interests of all countries" from Article I and place it in the preamble was rejected.[2] Similarly, the draft of Article I(1) was modified when the words "irrespective of their degree of economic or scientific development" were moved on the basis of a consensus from initial position in the preamble to their present position

following the "common interests" clause, because the developing countries advocated inclusion of the latter phrase as part of the binding treaty commitment.[3] Thus, it may be inferred that the drafters intended Article I(1) to be binding. Second, even if the provision is considered non-self-executing and the effectiveness of the limitation is thereby somewhat diminished, its binding character is not impaired and the legislative or executive acts necessary to implement the binding provision are nonetheless mandatory for all parties to the treaty.[4]

The content of the phrase "for the benefit and in the interests of all countries" in Article I(1) is also open to dispute. Some authorities take the position that the treaty's admonition to use outer space for the benefit of all members of the international community constitutes no more than a duty upon each member not to misuse outer space in a way which could diminish the value of space activities to other members.[5]

Others have taken the closely related position that the phrase means that the use of space objects should not be detrimental to the interests of other countries, including national security, public order and sovereignty over natural resources which are protected under international law.[6]

The third possible interpretation would impose on space powers the obligation either to permit other countries to use the former's space vehicles or to share the financial benefits of its space activities. Arguments supporting this position have been raised in the discussions of the CPUOS Legal Sub-Committee

relating to direct broadcast and earth resources satellites.[7] To date, that approach has received little direct international support.[8] Nonetheless, a similar approach relating to the exploitation of resources in another area located beyond the limits of national jurisdiction, the deep seabed, has received substantial support during the present series of United Nations Conferences on the Law of the Sea.[9] Although a scheme for licensing exploitation of the orbit and distributing the proceeds equitably among the members of the international community has been proposed, current developments in space law and the law of the sea suggest that final agreement on such an arrangement is not likely to occur in the near future.

An analysis both of relevant arguments and of trends in the interpretation of Article I(1) as it applies to the utilization of outer space for industrial purposes indicates a number of conclusions. First, as an operative element of a treaty, Article I(1) is binding upon all states which are parties to the treaty. Second, the content of the "common interests" clause is unclear and therefore requires further elaboration. As a result, the clause may be considered non-self-executing for purposes of space industrialization. Third, although the clause's content is disputed at a minimum, it imposes a duty upon states to use outer space in such a way that neither the earth-bound interests of other states, including national security, or the potential interests of the latter in the exploration or use of outer space are jeopardized. Finally, although the upper

limit of the "common interests" requirement is unclear under existing space law, Article I(1) does not require space powers to share either their space vehicles or the profits derived from space activities with non-space powers.

The impact of Article I(1) upon space industrialization depends on the precise nature of the activity contemplated. Communications satellites utilize segments of the electromagnetic spectrum and portions of the geostationary orbit. Although both are potentially subject to overcrowding, unilateral use of transmission frequencies or orbital slots would not violate Article I(1), since transmitter and space shuttle technology and the potential ability to remove inoperative satellites from orbit emphasizes the character of both the spectrum and the geostationary orbit as renewable resources-which are non-depletable in any permanent sense. Most applications would not jeopardize any of the essentially terrestrial interests protected by Article I(1). However, some nations have argued that the use of satellites for the transmission of television programs directly to home or community receivers could interfere with the internal political or economic stability of "receiving states."[10] Although some concern may be justified despite good faith efforts by all participating parties, the question will be decided in the context of a separate declaration relating to direct broadcast satellites, rather than in the context of Article I(1).

The impact of "common interests" clause on satellite remote sensing is likely to be somewhat similar to its effect on

communications applications. Although some sensing satellites--primarily those designed for earth resources applications--operate in low earth orbit, others, including meteorological satellites, are likely to occupy geostationary orbital slots. As noted above, use of the geostationary orbit consistent with the applicable regulations of the International Telecommunication Union (ITU) is not impeded by Article I(1). However, some questions have arisen regarding interference with the national security and economic interests of sensed states arising from potential abuses of earth resources applications of remote sensing technology. As a result, efforts to limit the use of earth resources satellites or to place their use in the context of a somewhat restrictive organizational structure have been initiated in the United Nations.[11] Although reference has been to Article I(1) in the debates, the result of these debates is likely to take the form of an international declaration of principles which does not refer directly to the content of that provision.

If satellite power systems are implemented either experimentally or operationally, four main questions are likely to arise in the context of the "common interests" clause. First, since such systems are likely to occupy segments of the geostationary orbit to facilitate either power production or transmission, and since the size of such satellites will require significantly larger slots than are presently utilized by communications and meteorological satellites, the question of orbital slot alloca-

tion will undoubtedly arise. However, Article I(1) does not present an obstacle. Second, as presently conceived, a satellite power system would not affect adversely a state's sovereignty over its natural resources, its political, social, cultural and economic self-determination or domestic order among its citizens. Consequently, those interests would not inhibit establishment and operation of a satellite power system. A third potential concern could arise among energy-producing countries that the establishment of such systems by energy-consuming countries could undermine the economies of the former. However, as suggested below in Section I.C., international law does not protect countries against either economic competition or economic pressure.

Finally, the laser or microwave transmission mechanisms likely to be used by satellite power systems to convey power generated in orbit to relay stations on the earth's surface may be said to constitute potential weapons for use against the earth's surface. If the weapons potential were realizable, the system *qua* weapon would be contrary to the interests of non-allied countries protected by Articles I(1) and IV. However, the assumption of the present memorandum is that satellite power systems will incorporate adequate safeguards to prevent their use as weapons and hence would not violate the interests of other states embodied in Article I(1).

Operation of manufacturing facilities in outer space would not adversely affect any of the terrestrial interests of states

with the possible exception of adverse economic influence resulting from the relative scarcity of products manufactured in outer space and the accompanying high cost. As noted above, this fact is insufficient in itself to present any restriction on space operations. Since manufacturing facilities would not necessarily require placement in geostationary orbit, interference with the space-oriented interests of non-participating states in access to particular areas of outer space is not likely to occur. However, since those facilities are likely to generate various forms of waste ranging from harmless gases to debris and nuclear by-products, potential interference with the space activities of other states, the provisions of Articles I(1) and IX probably require the operation entities to take reasonable steps to identify and avoid such potential interference.

In addition to the interpretation of the "common interests" clause an assessment of the impact of Article I(1) on the use of outer space for industrial purposes raises a set of issues centering around the argument that Article I(1) requires states to use outer space "for exclusively peaceful purposes."[12] Even assuming for the purposes of this analysis that the Article I(1) requirement that outer space be used "for the benefit and in the interests of all countries" contains within it the requirement that outer space be used "exclusively for peaceful purposes,"[13] the United States' position on the question significantly diminishes the extent to which the latter requirement could inhibit the industrialization of outer space. However,

pressure from other governments could lead to general acceptance of a more restrictive approach.

The main point of contention is the meaning of the term "peaceful uses." Regardless of their respective positions on the question of content, authorities agree that the main interpretational alternatives are limited to two: "peaceful uses" can be defined either as "non-aggressive uses," leaving open the possibility of the use of outer space for defensive military purposes or as "non-military uses," excluding both aggressive and defensive activities.[14]

The possibility that Article I(1) implicitly incorporates the "peaceful use" requirement is based on the language of that provision and on the context in which the treaty was drafted. Applying the requirement that space activities be conducted "for the benefit and in the interests of all countries" to the question of military action in outer space, some authorities conclude that the space activities can be conducted in the interests of all countries only if they are "peaceful" in nature.[15] In addition, it may be argued that since the term "peaceful" is ambiguous and subject to conflicting interpretations, especially in the context of a general statement of desirable purposes of space initiatives, the drafters chose to substitute the concept of use "in the interests of all countries."[16] Finally, proponents of the "peaceful use" requirement maintain that since Article IV and other provisions of the treaty did not completely prohibit placement of weapons in outer space, the term "peaceful uses" was omitted from Article I to avoid ambiguity.[17]

The case for the opposite position is based on the formulation of Article IV, which in Paragraph 2 expressly limits activities on the moon and other celestial bodies to exclusively peaceful purposes, but in Paragraph 1 omits any such limitation. Although some advocates of the "peaceful use" interpretation of Article I(1) explain the omission as the result of imprecise drafting,[18] the omission must be considered intentional since an attempt to apply the phrase "exclusively for peaceful purposes" to all areas of outer space was defeated.[19] Since the Article IV approach is expressly stated, and is supported by the "free use" principle of Article I(2), it cannot be altered by inferences based on less explicit language.

Similar arguments apply to the dispute regarding the definition of "peaceful uses." In support of the "non-military" interpretation it is argued that military activity can never be "peaceful" and even purely defensive weapons cannot be in the interests of all states.[20] On that basis, it is argued that adoption of Article I(1) embodying the expression of one of the most fundamental principles of space law operates to prohibit even defensive weapons in outer space.[21]

The opposite view is based on the contention that "non-aggressive" uses are permitted, first, by Article IV(1) which prohibits the stationing of weapons of mass destruction in outer space but omits the express requirement of peaceful uses applied by Article IV(2) to the celestial bodies, and second, by Article III which requires states to conduct space activities in accordance with international law, including the United Nations

Charter. Neither prohibits defensive or non-aggressive military activity. Support for this approach is also found in the practice of states. Both major space powers use outer space for military communications and reconnaissance. Although these activities are "military" in nature, they are "non-aggressive."

Balancing of these arguments and the underlying policy considerations leads to the conclusions

1. that although Article I(1) requires states to conduct space activities "for the benefit and in the interests of all countries," it does not prohibit all military activity in outer space; and
2. that Articles I(1), III and IV combine to limit any military activity in outer space to "non-aggressive" conduct.

These conclusions suggest that under present international space law, stationing military installations and weapons systems in orbit may be permissible if they are defensive in nature and do not contain nuclear weapons or other instruments of mass destruction. Hence, the operator of a satellite power system may be permitted to convey its products to orbital or terrestrial military installations which are designed for defensive purposes. The need to distinguish defensive from offensive purposes may present a problem for the system operating in this context. Finally, if used exclusively in conjunction with defense-oriented systems and installations, the system may be operated by military personnel.

In general, activities relating to space industrialization are not in themselves either aggressive or defensive as those terms are used in a military context and hence would not violate the alleged requirement that outer space be used exclusively for peaceful purposes. However, in some cases, non-space powers may argue that direct television broadcasting and satellite remote sensing constitute "aggressive" activities and should therefore be restricted. In the absence of other facts, however, the current state of international law in this area would not support these contentions.

Although not "aggressive" on their face, space industrialization activities may be deemed aggressive because of the uses made of the resulting products. The generations of electrical power in orbit is illustrative for these purposes.

Satellite generated power could be put to three arguably military uses:

1. directly as a weapon used to attack terrestrial or space targets for aggressive or defensive purposes;
2. to provide energy for the support of military installations and weapon systems in orbit or on earth, or
3. to relieve civilian demand on terrestrial power generation facilities to ensure an adequate supply of energy to terrestrial military installations.

The first use constitutes the main subject matter of Section III.D. of Part II and is examined there in the context of Article IV of the Outer Space Treaty. The connection of the third possible use to military activities is too tenuous to support application

of the prohibition of any military use of outer space inferred by some authorities from the language of Article I(1). In addition, a parallel approach could be used to prohibit national exploitation of the minerals of the deep seabed for civilian use, since that could increase the supply of minerals available to the nation as a whole and hence to its military organizations. That result is, however, directly contrary to the express provisions of the international legal regime of the high seas which both reserves use of the deep seabed for exclusively peaceful purposes and authorizes exploitation of seabed minerals without reference to their possible use for military purposes.[22]

Thus, only the second possibility--that of direct use of satellite generated power by military installations or weapons systems--poses a potential problem under the alleged requirement that outer space be used exclusively for peaceful purposes. If some or all of the power is used by an orbital weapons system which clearly is in violation, for example, of the Article IV(1) prohibition on the stationing of weapons of mass destruction in orbit or by a military installation located on a celestial body in violation of Article IV(2), the use of outer space for generating power would be unlawful to the extent that its power products are consumed by the prohibited system installation. The result is less clear when the power products are consumed by a military installation or weapons system which is either legally in orbit or is located on the earth. If power generated by a satellite is utilized by a military installation or weapons system which is legally in orbit,[23] the use of outer space for the power generation activity would be permissible under the "free use"

principle of Article I(2). The legality of the stationing of the installation or weapons system in question must be determined by reference, first, to the specific prohibitions of Article IV, and second, to the debate regarding the content of the alleged "peaceful use" requirement.

As set forth in greater detail in Section I.D. below, Article IV specifically prohibits a series of three activities in outer space:

1. the stationing of nuclear weapons or other weapons of mass destruction in orbit around the earth or elsewhere in outer space;
2. the stationing of such weapons on the moon and other celestial bodies,
3. the use of the moon and other celestial bodies for any except exclusively peaceful purposes, as a result, the establishment of military bases, installations and fortifications, the testing of weapons of any kind and the conduct of military maneuvers in those areas is forbidden.

As suggested above, some authorities argue that the Article I(1) requirement that outer space be used "for the benefit and in the interests of all countries" includes a requirement that space be used exclusively for peaceful purposes. If that argument can be sustained, the activities of states in outer space would be further limited. The extent of the limitation would depend on whether all military activities or only aggressive activities would be prohibited.

2. *Article I(2): The "Free Use" Principle*

The second paragraph of Article I contains two main provisions which are likely to influence the industrialization of space. The most important, the "free use" principle, provides that "outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States . . . ." This "free use" principle provides the international legal basis for all activity in outer space. In contrast to the restrictions imposed by other sections of the Outer Space Treaty, Article I(2) affirmatively authorizes space activities, and hence serves as the point of departure for any argument in favor of a particular use of outer space. For that reason Article I(2) has played an important role in the protection of space initiatives against unnecessary restrictions.

Thus, although the "free use" principle is one of the key provisions of the Outer Space Treaty, and is sufficiently broad to sustain the right of states to conduct activities in outer space free from claims of sovereignty of subjacent states, it is not unlimited.

As suggested above, Article I(2) must be read in the context of the "common interests" clause of Article I(1) with the result that the advantages to be derived from rapid development of outer space must be balanced against the requirement that the development be carried out in a manner beneficial to all members of the international community. In that combination, the "free use" clause creates a tendency to limit the

potential inhibiting effect of a restrictive construction of Article I(1). As applied to the industrialization of outer space, the "free use" principle has provided the conceptual basis for resisting arguments that activity in outer space is unlawful in the absence of clear and convincing evidence that it is being conducted for the benefit and in the interest of all countries in accordance with Article I(1).[24] Consequently, Article I(2) tends to shift construction of Article I(1) toward the minimal duty to avoid conducting space activities in a manner detrimental to the interests of non-participating states as described above. In addition, the "free use" principle is subject to the prohibitions both of Article II relating to non-appropriation and of Article IV dealing with the stationing of nuclear weapons in outer space. To the extent that space industrial activities are likely to contaminate either outer space or earth, the "free use" principle is also limited by Article IX.[25]

B. Article II: Non-Appropriation in Outer Space

The second major limit on the "free use" principle is embodied in Article II, which provides:

> Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.

The non-appropriation principle is likely to affect the activities associated with space industrialization which involve either consumption of space resources or utilization of the geostationary

orbit. The language of Article II raises three main issues with respect to industrial development in space:

1. the subject matter to which the prohibition applies;
2. the meaning of the term "appropriation", and
3. the validity of "appropriation" by entities other than national governments.[26]

The listing of space industrial activities set forth in Part I contains two types of resource utilization. First, satellite power systems arguably "appropriate" solar energy. However, with respect to solar energy the Article II prohibition clearly does not apply. One of the primary purposes of Article II is to implement the "free use" policy of Article I(2).[27] Article II must therefore be construed to promote rather than inhibit the exploration and use of outer space. Nearly all satellites presently in service or planned for the near future will depend on conversion of the sun's energy to electrical power for use in the operation of their respective payloads. Large-scale use of alternative energy sources by satellites has proven impractical. As a result, application of the Article II prohibition to the use of the sun's energy would sharply limit the scale, duration, and hence, the economic viability of space development projects. Further, in the absence of special circumstances, enforcement of Article II against the "appropriation" of essentially inexhaustible space resources would serve little purpose,[28] and should be avoided

in favor of the "free use" principle. Since the same policy considerations apply to conversion of solar energy for use on earth as well as for use by satellites in orbit, Article II probably does not limit the use of solar energy by satellite power systems.

Second, extraction of mineral ores and other substances from the moon or other celestial bodies, which may eventually constitute one of the most significant commercial space activities, arguably constitute "appropriation" in violation of Article II. As noted below,[29] both the United States and the Soviet Union have taken the position that although Article II prevents a country from exercising sovereign control over portions of the moon, it does not interfere with exercise of proprietary rights over natural resources after they have been separated from the moon's surface or subsurface. However, the interpretation of Article II is a central issue in the negotiations relating to the draft moon treaty before the CPUOS Legal Sub-Committee. Final resolution of the dispute which has delayed conclusion of the moon treaty will also depend on establishment on the question of potential rights of each member of the international community to exhaustible lunar resources.

The second category of space industrial activities which could be significantly affected by Article II require utilization of the geostationary orbit. In theory, earth resources and communications satellites, and satellite power systems could be said to "appropriate" segments of the geostationary orbit.

The use of a particular orbital slot is undoubtedly subject to the terms of Article II, especially in light of its function of providing support to the "free use" principle. The question is most pressing for orbital power generation, and the analysis below applies <u>a fortiori</u> to other satellites in geostationary orbit. Because of the projected dimensions of a solar power satellite,[30] the size of the orbital slot required for safe operation is substantially greater than that required for existing communications or meteorological satellites. In addition, stress factors resulting from the necessary length of support beams suggest the need for safety zones similar in concept to those established for installations engaged in exploitation of the resources of submarine areas.[31] Although the Article II prohibition clearly applies to the appropriation of a particular orbital slot, the determination of the validity of placing a solar power satellite in geostationary orbit is dependent on the meaning of the term "appropriation" as used in Article II.

Analysis of the concept of "appropriation" suggests the existence of two subsidiary elements:

1. exclusive use; and
2. relatively permanent use, including consumption.[32]

It has been argued that since use of a particular orbital slot by a geostationary satellite is temporary, the requirement of permanence is absent and the use of the orbital slot cannot be considered an "appropriation" within the meaning of

Article II.[33] Other authorities conclude that national use of particular segments of the orbital arc deprives other states of the opportunity to use the same area and therefore constitutes appropriation through occupation.[34] The key issue is the permanence of the use. Evaluation of the economic viability of a satellite power system is based on the assumption that the system would operate for up to thirty years.[35] Although that period is extended, it does not indicate the permanence necessary to invoke the prohibitions of Article II. However, longer periods could exceed the limit and come within the purview of Article II.

The third issue raised by the Article II prohibition focuses on the identity of the system operator. Article II appears to prohibit only national appropriation, suggesting that even permanent use of an orbital slot by international organizations or commercial entities would not necessarily constitute a violation of that provision.[36] Consequently, a commercial consortium would not be prohibited under Article II from maintaining a solar power, earth resources or communications satellite in a particular orbital slot for an indefinite period. Similarly, subject to establishment of a clear distinction from other types of organizations, an "international" organization would not be prohibited either from operating a similar system or allocating orbital slots among its members. For that reason, the activities of the International Telecommunication Union described below in Section III relating to the management of the geostationary orbit do not violate Article II.

Three potential limitations on these conclusions should be noted. First, the interpretation set forth above would not permit commercial or international organizations from claiming exclusive rights to a particular area of outer space in the absence of actual use. Thus, if such an organization had maintained a satellite in a specific orbital slot for a substantial period of time and the satellite's station-keeping systems subsequently failed, the organization would not be entitled to prevent any other entity from occupying that slot pending orbiting a replacement satellite by the original occupant. Second, if an entity were established which although commercial in form was essentially under the control of the government of the country in which it is organized, permanent use would constitute national, as distinguished from non-national, appropriation.[37] Third, dispute has arisen regarding the minimum standard of universality which would determine whether an international organization would be implicitly exempted from the rule of non-appropriation. Professor Jenks has argued that only the United Nations as a representative of the whole international community should be exempt.[38] Presumably any intergovernmental organization of relatively universal membership satisfies the minimum standard. However, some question remains regarding the exemption of an organization composed of a limited number of governments.[39]

Thus, the Article II prohibition against the appropriation of outer space applies to exclusive use of a segment of the geostationary orbit. However, the prohibition does not apply

to the activities of either non-governmental entities or relatively comprehensive international organizations. The implications of the non-appropriation provision for space industrial activities are further limited by the conclusion that since the use contemplated is not permanent, exclusive use for a limited period of time would not constitute "appropriation" as that term is used in Article II. Hence, regardless of the operating entity's institutional structure, it can expect to conduct industrial activities in geostationary orbit without concern that its action violates Article II.

C. Article III

Another fundamental principle affecting the utilization of outer space is the general applicability of international law as embodied in Article III, which provides:

> States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international co-operation and understanding.

As suggested in Subsections A and B above, Article III, through its reference to the United Nations Charter, affects industrial development of outer space, first, because it prohibits the aggressive use of military force, and second, because it does not prohibit the use of economic leverage for political purposes. In both cases, the key is Article 2(4) of the United Nations Charter which provides:

> All Members [of the United Nations] shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any state, or in any manner inconsistent with the purposes of the United Nations.

Interpretation of this provision in light of the remainder of the Charter suggests that the use of armed force is prohibited, except under certain specified circumstances when the use of force in self-defense is authorized.[40] Consequently, under Article III use of outer space for defensive purposes is not prohibited. That conclusion is strengthened by the language of Article IV as described below in Section I.D.

In connection with the analysis of Article I(1) in Section I.A. above, it was suggested that international law would not prohibit the operator of a space industrial facility from engaging in economic competition with other countries which produce similar products or from using the availability of the products of those facilities to exert economic pressure on consuming countries as a means of political persuasion. Construction of Article 2(4) of the Charter limiting its prohibition to the use of armed force is a significant part of the conceptual underpinnings of that proposition. The conclusion that economic leverage is not prohibited under Article 2(4) is supported by significant authority.[41] In addition, that conclusion is consistent with prevailing general international law.[42] As a result, the system operator need not be concerned that any means of selecting or limiting consumers of the system's products contravenes existing international law.

D. Article IV

Some of the applications listed in Part I could be converted to military purposes. Article IV of the Outer Space Treaty, which limits these possibilities, provides in part.

> States Parties to the Treaty undertake not to place in orbit around the earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.

The language of Article IV raises two main issues:

1. the implications for industrial development of outer space of the Article IV prohibition against the stationing of weapons of mass destruction in orbit; and
2. the impact on Article IV on plans to establish military facilities in orbit for the protection of a satellite power system from attack.

In Section I.A.2. above, analysis of Article IV in the context of the concept of the exclusive use of outer space for peaceful purposes suggested, among others, the conclusion that Articles I(1) and IV(1) implicitly authorize the establishment of military installations and weapons systems in outer space -- but not on the celestial bodies -- which are exclusively defensive in nature, provided they do not contain nuclear weapons or other weapons of mass destruction. Of the activities described in Part I, only satellite power systems and their microwave or laser transmission beams appear likely

to be adaptable for direct use as weapons. The possibility that the products of industrial facilities in outer space could be used for military purposes is discussed in Section I.A.2. above.

Because of the nature of the transmission beam, the argument may be made that the establishment of a satellite power system potentially constitutes the stationing of a weapon of mass destruction in outer space in violation of Article IV. The system operator can make at least three responses. First, the system is designed not as a weapon but as a utilitarian device for the efficient use of solar resources. Any of the present designs incorporates a series of safety devices to terminate transmission of power when the transmission beam moves outside the intended reception area.[43] Although the selection of a laser transmission beam could constitute a safety hazard, the tendency among designers is toward the use of a microwave beam which is considered less dangerous.[44] Nonetheless, the potential harm from a microwave beam should not be underestimated.[45] Second, in geostationary orbit the satellite's configuration and location would limit its use as a weapon. Third, the system is not likely to be operated by military or national security entities and is therefore less susceptible to use as a weapon. Thus, although use of a satellite power system as a weapon is clearly prohibited under Article I.V.(1), the probability of such use as well as the value thereof is rather small.

Application of Article IV to the establishment of military installations in space to protect space industrial facilities is somewhat more complex. Once established, space industrial facilities, especially those in geostationary orbit, would present a desirable target for military or terrorist action. The large size of power generation and manufacturing structures would increase the margin of error for targeting purposes and therefore decrease the level of military sophistication required to ensure reasonable probability of a successful attack. In addition, the potential importance of industrial facilities to a nation's economic, political and military potential suggests that destruction of the system would be assigned a high priority in time of military or political conflict. Finally, because an attack on the system could create significant social and political impact without jeopardizing human life, the system would represent a desirable target for symbolic actions.

In theory, Article VII of the Outer Space Treaty and the procedure established in the Convention on International Liability for Damage Caused by Space Objects would provide remedies for any damage except that caused by actions taken, against the system not involving a space object. A laser attack originating from a terrestrial installation is a possible example. However, the procedures established by treaty are not likely to be effective, especially in cases of deliberate destruction. First, extensive delays must be

anticipated prior to resumption of service, with obvious consequences for the launching state's economic stability. Second, since diplomatic claims settlement procedures are involved, full recovery of damages specified in Article XII of the Convention in Liability is not likely, first, because damage claims are often discounted, and second, because few countries have the economic capacity to repay the cost of establishing a space installation. Third, a successful attack could create potential hazards from debris in space and, in the case of satellite power systems, from transmission beam spillover on the earth's surface.

In light of the foregoing considerations, some means of military protection is considered desirable. Terrestrial weapons systems are likely to be limited in their ability to defend space installations against attack either from outer space or from the earth. Hence, some form of defensive weapons system stationed in space in a position to protect the satellite power system appears necessary.

In Section I.A.2., an analysis of Articles I(1) and IV and the concept that outer space should be used exclusively for peaceful purposes led to two main conclusions:

1. the stationing of nuclear and other weapons of mass destruction in outer space is prohibited;
2. military activity in outer space is not prohibited if it is defensive or non-aggressive in nature.

The same principles apply to the establishment of a weapons system in space for the protection of the space segment of space industrial facilities. In principle, Articles I(1), III and IV do not prohibit the establishment of such a weapons system provided it does not incorporate weapons of mass destruction or require the use of installations on the moon or other celestial bodies.

Some difficulty could arise, however, if a protective system were incorporated which purported to be defensive in nature but which could be trained on earth or other celestial bodies, or upon large space objects and used for aggressive as well as defensive purposes. Although it could be argued that the exigencies of national security and modern warfare require such flexibility, the dual purpose approach would undermine the rationale for omitting defensive weapons systems from the prohibitions of Article IV. As a result, such systems may be considered unlawful to the extent that they are capable of inflicting mass destruction.

E. Article VI[46]

Article VI, which establishes the foundations for international responsibility for activities in outer space provides:

> States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental

> entities in outer space, including the moon and other celestial bodies, shall require authorization and continuing supervision by the State concerned. When activities are carried on in outer space, including the moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization.

Thus, each state which is a party to the treaty is charged with the obligation, first, to ensure that the activities of its nationals comply with the provisions of the treaty, and second, to accept responsibility for those activities which contravene applicable provisions. In this manner, states are unable to avoid the duty of compliance through the use of institutional configurations which do not involve elements of the national government.[47] Consequently, the responsibility of each state's government is not affected by the juridical character of the entity actually operating the satellite power system.

A state's duty to supervise the activities of its nationals for practical purposes probably prohibits unregulated, private undertakings.[48] Article VIII of the Outer Space Treaty reinforces the obligation by requiring the state under whose registry an object is launched into outer space to retain control and jurisdiction. In light of the potentially hazardous character of many activities related to industrial development in outer space, especially satellite power generation, the policy considerations underlying Article VI suggest the need for relatively strict supervision.[49] The provisions of Article VII

and the Convention on International Liability for Damage Caused by Space Objects,[50] which impose liability on the launching state for damage resulting from space activity, are likely to give rise to practical and foreign policy considerations which create pressure upon national governments to exercise the supervision necessary to ensure protection against the potential hazards of orbital power generation.

Although governments are required to ensure compliance of their respective nationals with appropriate provisions of the treaty, Article VI does not have the effect of subjecting non-governmental entities to provisions which would otherwise not apply to them. For example, as suggested above in Section II.A., Article II does not apply either to private sector entities or to international organizations. Although terms of Article VI require states parties to the treaty to ensure compliance of their nationals with its provisions, Article VI does not extend the prohibition against appropriation to entities which are not covered by the terms of Article II.

F. Article VII

Article VII, which embodies the fundamental principles governing liability for danger arising from space activities, provides.

> Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the moon, and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its

> natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the moon and other celestial bodies.

Because of the wide range of potential environmental and other hazards which could be created by establishment and operation of space industrial facilities, the question of liability is particularly significant. Potential injuries include:

1. Damage to body tissue of humans and wildlife exposed to nuclear and electromagnetic radiation;
2. Radio frequency interference;
3. Interference with electronic instrumentation, especially devices associated with medical, navigation, and explosives detonation activities; and
4. Environmental modification, including weather and climate alteration, resulting from increased heat generation and interaction of the transmission beam and launch vehicle exhausts with the upper atmosphere and ionosphere.[51]

If injury results from the operation of a satellite power system, the injured party is entitled to redress under Article VII. Under its terms, the state which procured the launch of the vehicle causing the injury and the state which launched the space object are internationally liable to the entity actually injured, or to its national government. The language of Article VII raises two main issues.

1. the meaning of the word "damage"; and
2. the meaning of the phrase "internationally liable."

Although the terms of Article VII provide no guidance on these issues, the broad principles of Article VII were implemented in the Convention on International Liability for Damage Caused by Space Objects. Since Article VII raises no issues which are distinguishable from those raised by application of the Liability Convention to space industrialization, discussion of the Article VII principles is incorporated in Section II of this Part, which examines the Liability Convention.

G. Article VIII

Article VIII of the Outer Space Treaty, pertaining to the ownership and control of objects in outer space provides:

> A State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel therefor, while in outer space or on a celestial body. Ownership of objects launched into outer space, including objects landed or constructed on a celestial body, and of their component parts, is not affected by their presence in outer space or on a celestial body or by their return to the Earth. Such objects or component parts found beyond the limits of the State Party to the Treaty on whose registry they are carried shall be returned to that State, which shall, upon request, furnish identifying data prior to their return.

The first sentence assists implementation of the provisions of Articles VI and VII relating to international responsibility and liability for activities in outer space, particularly over nationals operating in non-governmental capacities. Although the nature and scope of national control is likely to vary from country to country, possibly giving rise to a "flag of convenience" practice in outer space, Article VIII is

likely to introduce or increase regulatory limitations on industrial development in outer space. Consequently, entities which are interested in participating in the development of outer space should anticipate that current developments in regulatory concepts and practices are likely to serve as precedents for regulation of space activities. Hence, those entities should consider whether regulatory developments in relevant areas, both substantive and geographic, should be monitored for purposes of identifying trends and formulating plans for participating in the evolution of regulatory structures.

The second sentence is considered extremely important to institution of operational industrial services in outer space. By protecting the rights of ownership as established in accordance with traditional international law, Article VIII provides the basis for industrialization of outer space under both commercial and national governmental organizational structures. As suggested below in Section IV, the capital investment necessary to develop, establish and operate a satellite power system would be deterred or completely prevented if rights of ownership are not protected.

H. Article IX

Article IX, the final provision of the Outer Space Treaty which is likely to affect the industrialization of outer space, provides:

> In the exploration and use of outer space, including the moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space, including the moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extra-terrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the moon and other celestial bodies, may request consultation concerning the activity or experiment.

Like Article II, Article IX operates as a limit on the "free use" principle of Article I(2). The key provision contained in the first sentence of Article IX requires states to "conduct all their activities in outer space . . . ., with due regard to the corresponding interests of all other States Parties to the Treaty.[52] The remaining three sentences implement the "due regard" requirement.[53]

The limitation contained in the first sentence is particularly relevant to the use of the geostationary orbit, where

the problem of conflicting uses is complicated, first, by potential interference among satellites which are located in proximity to one another, and second, by disputes between countries which intend to use a particular orbital slot in the present or the near future and countries which plan to use the same slot in the more distant future and which are therefore concerned about preserving their future interests. In an effort to promote resolution of these potential conflicts, Article IX provides the basis for consultation among the concerned parties.[54] The general policies of Article IX are applied to the utilization of the geostationary orbit by the International Telecommunication Convention and the Radio Regulations periodically revised by ITU conferences.

The second sentence, which requires states parties to the treaty to conduct activities in outer space so as to avoid both harmful contamination of outer space and adverse changes in the earth's environment resulting from the introduction of extraterrestrial matter, could limit operation of space industrial facilities, if liberally construed. On its face, the second sentence is limited to environmental hazards potentially created by extraterrestrial <u>matter</u> brought within the earth's biosphere. Although the distinction between matter and energy is not yet precisely defined for these purposes, the passage of the satellite power system transmission beam, for example, through the earth's atmosphere appears to fall outside the scope of the second sentence.

However, the combination of the first two sentences may have the effect of extending the prohibition to the introduction of any physical phenomenon which could adversely affect the earth's environment. The first sentence implicitly incorporates at least conceptually the requirement of Article I(1) that outer space be used "for the benefit and in the interest of all countries."[55] To the extent the two provisions are coextensive, the first sentence would require space powers to conduct their space activities in a manner which does not prejudice the "corresponding" interests of non-participants. The definition of the term "corresponding" is not clarified, but presumably encompasses both space and terrestrial interests likely to be affected by space activities, in a manner comparable to the "common interests" clause of Article I(1).[56] Consequently, Article IX requires that consideration be given to the elimination of the adverse effects listed above,[57] especially to the extent they effect the interests of states other than the state conducting the activity in question.

The third and fourth sentences establish a minimum standard for "due consideration." If the state undertaking the activity has reason to believe that activities planned by it's nationals are likely to cause harmful interference with the activities of other states parties to the treaty, it is obligated to "undertake appropriate international consultations" with the affected states prior to implementation of its plans. Similarly, if one party has reason to believe that the activities

of another party would cause potentially harmful interference with activities relating to the exploration and use of outer space, the former may request such consultations, even if its own activities would not be adversely affected.[58] The consultation provisions raise three key issues.

1. when does a party have sufficient "reason to believe" that harmful interference would result from the planned activities?
2. what constitutes harmful interference?
3. what are the characteristics of "appropriate international consultations?

Under the language of the third sentence of Article IX, the obligation of a state planning to engage in space activity becomes operative when it has "reason to believe" that execution of plans would cause harmful interference with the activities of other states in outer space. Thus, the determination that the obligation has become operative is solely within the discretion of the launching state. If it lacks sufficient information relating either to interference factors or to the plans of existing space activities of other states, the launching state is authorized to proceed without consultation.[59] The scope of this discretion may be limited, however, by communications from states whose space activities would be adversely affected or from third states to the launching states informing the latter of potential interference and requesting consultations as provided in the fourth sentence of Article IX.

Article IX does not provide a clear standard for determining when the activities of one state "could cause potentially harmful interference" with the activities of another. The language of the third sentence suggests that only interferences with the space activities, as distinguished from the earth-bound activities, of another state are relevant; however, since a large proportion of space activity necessarily involves support activities on the earth's surface, interference with those also gives rise to the consultative obligation of Article IX.[60] Further, interference can only occur with respect to activities which constitute "peaceful uses of outer space.[61] Presumably, the term "interference" is used in its ordinary meaning to signify conflicting uses resulting in obstruction, creation of significant hazards or significantly diminishing the efficiency of space activities.

The characteristics of "appropriate international consultations" are left undefined. From the context, the term "consultation" refers to the joint examination -- including the exchange of relevant information -- of the proposed activities and the probable consequences for each consulting party's interests.[62] Since the term "consultation" was selected by the drafters of Article IX, the parties are obliged only to make a good faith effort to conduct the joint examination with a view to reaching satisfactory resolution of conflicts among the consulting states. However, Article IX imposes no obligation to achieve reconciliation.[63] Although the form or

forum of consultation is not significant, the consultation must involve either diplomatic or scientific elements of the affected governments. As emphasized by the use of the word "international," the duty to consult is primarily bilateral in nature although consultation under the auspices of an intergovernmental organization is not precluded.[64] The suggestion that Article IX consultation must include all parties to the Outer Space Treaty cannot be supported.[65]

Thus, Article IX would require operators of space industrial facilities to conduct their activities with due regard at least to the space activities of other states. Although that requirement is likely to affect most directly the use of the geostationary orbit, it imposes a duty to remain alert to the possibility of adversely affecting the space interests of other states. In those cases where adverse consequences are likely, the operator is required to consult in good faith with the affected parties, with a view to the elimination of those consequences. However, the Article IX duty to enter into appropriate consultations does not impose an obligation to accept unnecessary restrictions on the operation of industrial facilities in space. Nonetheless, participation in such consultations by the government of the state whose nationals are conducting the space operations in question must be anticipated. Such participation is likely to limit the flexibility of space industrialists in their consultations, by applying pressure based on national foreign policy interests.

II. CONVENTION ON INTERNATIONAL LIABILITY FOR DAMAGE CAUSED BY SPACE OBJECTS

Article VII of the 1967 Outer Space Treaty established a basis for the imposition of liability for damage or injury caused by a space object. However, due to the general nature of its provisions, Article VII did not create specific principles directly applicable to damage actually resulting from space activity. In an effort to formulate appropriate principles, the Committee on the Peaceful Uses of Outer Space (CPUOS) stepped up its consideration of questions of liability. As a result, a draft convention was submitted to the General Assembly and adopted on November 29, 1971, in Resolution 2777 (XXVI).[1] The convention entered into force for the United States on October 9, 1973.[2] In its present form, the convention contains six main sections:

1. Articles I-VII establish the fundamental principles of liability and scope of coverage,
2. Articles VIII-XX set forth guidelines for presentation and prosecution of claims,
3. Article XXI provides for special assistance in the case of damage on a massive scale;
4. Article XXII generally applies the rules of liability to international intergovernmental organizations;
5. Article XXIII limits the convention's impact on other international agreements; and

6. Articles XXIV-XXVIII establish the procedures for signature, amendment and entry into force of the Convention.

A. <u>Articles I-VII</u>

Article I contributes to the delimitation of the scope of the convention, through its definitions of "damage" and "launching state." Article I(a) defines "damage" to mean

> loss of life, personal injury or other impairment of health, or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations . . . .

Although undoubtedly covering damage directly resulting from launch or operation of a space object, that language leaves open the question whether the definition covers consequential or non-physical damage.[3] Since many of the potential damage categories associated with space industrialization[4] are either consequential or non-physical in nature, the ambiguity is significant for entities potentially involved in space activities. A survey of relevant authority suggests that the range of damage categories intended to be covered is relatively broad.[5] Consequently, impairment of mental and social well-being are likely to be covered.[6] Loss of consortium, other forms of "moral" damage, as well as forms of non-physical damage, including electronic interference are probably not covered.[7]

The second element of Article I which contributes to the definition of the convention's scope is Paragraph (c) which defines the term "launching State" to mean.

> (i) A State which launches or procures the launching of a space object
>
> (ii) A State from whose territory or facility a space object is launched . . . .

This definition is significant, since the liability described in subsequent articles is imposed on the "launching State." The content of Article I(c) is based on Article VII of the Outer Space Treaty and is consistent therewith. As discussed in greater detail below,[8] the possibility that liability could be imposed on three separate governments for damage caused by a space object raises procedural complications which must be antipated.[9]

Another ambiguity is created by the definition in Article I(d) of the term "space object," which provides:

> (d) The term "space object" includes component parts of a space object as well as its launch vehicle and parts therof.

Although by its terms, Article I(d) clearly covers a launch vehicle and each of its components, as well as a "space object" and its components, the language does not provide clear guidance regarding the nature of a "space object." That term is used in the Outer Space Treaty to describe objects launched into outer space (Articles VII and VIII), objects in orbit around the earth (Article IV) or objects which are simply launched (Article X).[10] Natural objects such as asteroids are probably excluded unless some means of independent propulsion were constructed on it.[11] Similarly, a question mav be raised regarding the status of objects which are manufactured or assembled in orbit.

Other limits on the applicability of the convention are contained in Article VII, which excludes from coverage:

> (a) Nationals of [the] launching State;
>
> (b) Foreign nationals during such time as they are participating in the operation of [a] space object from the time of its launching or at any stage thereafter until its descent, or during such time as they are in the immediate vicinity of a planned launching or recovery area as the result of an invitation by that launching State.

As a result, nationals of the launching state are limited to the judicial or administrative remedies provided by the law of the launching state. Presumably foreign nationals participating in the launch, operation and recovery of a space object would be limited to the same remedies.

Once it is ascertained, first, that the injury sustained falls within the scope of the term "damage" and resulted from the operation of a "space object" as those terms are defined in Article I, the convention imposes liability upon the "launching State." The nature of the liability depends upon the location at which the damage occurred. Thus, if a space object causes damage on the surface of the earth or to an aircraft in flight, Article II provides that the "launching State shall be absolutely liable to pay compensation" for the damage. In that case no proof of negligence is required and the launching state is liable even though it is able to demonstrate that it complied with all applicable standards of care.[12] Thus, if industrial activities in space result in injuries or damage to property on the earth's surface or while travelling

in an aircraft, the launching state would be liable to pay compensation upon demonstration

1. that the injury occurred, and
2. that it resulted from the operation of space industrial facilities.[13]

The rationale for absolute liability is, first, that space acitivity is "ultrahazardous," and necessarily involves a risk of serious harm which cannot be eliminated by the exercise of utmost care,[14] and second, that the ability of a claimant state to demonstrate fault on the part of a launching is likely to be relatively limited.[15]

A possible weakness in the protection granted by Article II is based on the contention that it appears to not cover damage in airspace which does not affect aircraft in flight.[16] This omission is partially remedied by the likelihood that damage in the earth's atmosphere will result in injuries on the earth's surface which would constitute "damage" as that term is used in the Liability Convention. However, liability may be avoided by establishing that "the damage has resulted either wholly or partially from gross negligence or from an act of omission done with intent to cause damage on the part of the claimant State or of natural or juridical persons it represents," as provided in Article VI(1). In contrast, if damage is suffered in outer space, the launching state is liable for compensation to the injured party under the terms of Article III only upon a demonstration of fault of the launching

state or of persons for whom it is liable.[17] The rationale for differing treatment is based on the contention that the absolute liability imposed under Article II would be inappropriate for collisions between space objects, since the operator of the more costly object would collect the difference between the values of the space objects, even if the collision were caused completely or preponderantly by the acts of the more costly space object.[18] However, as a practical matter, the difficulty of demonstrating fault is likely to mean that in the event of damage to space objects, each party is likely to bear its own loss except in exceptional cases.[19] For both Articles II and III, the measure of damages is determined under Article XII which provides that when compensation is granted under the convention, the amount

> shall be determined in accordance with international law and the principles of justice and equity in order to provide such reparation . . . as will restore the person, natural or juridical, State or international organization on whose behalf the claim is presented to the condition which could have existed if the damage had not occurred.

Articles IV, V and VI introduce refinements of the general framework established in Articles II and III. Under Article IV(1), if damage is caused somewhere other than on the surface of the earth to the citizens of one state or their property as the result of the activities of a second state, and that interaction results in injury to the citizens or property of a third state, the first two are jointly and severally liable to the third state. If under Subparagraphs (a) and (b), the damage to the

third state occurs on the surface of the earth or to aircraft in flight, the liability is absolute; however, if damage is sustained by the third state's space objects to passengers or property on board, liability is based on fault. Paragraph 2 of Article IV apportions the liability between the first two states according to the extent to which each was at fault. If no comparative fault can be established, the liability is divided equally. Nonetheless, Article IV(2) expressly preserves the right of the third state to seek the entire compensation from any of the states which are jointly or severally liable.

Article V defines liability in cases in which two or more states jointly launch a space object. Under paragraph 1, all participating states are jointly and severally liable. After a state has paid compensation for damage caused by a jointly launched space object, it is entitled to seek compensation from other participants in the joint launching. The extent of each participant's liability may be determined by agreements among the participants, but such agreements do not prejudice the right of the state whose nationals have sustained damages to seek the full compensation from any or all of the launching states. Paragraph 3 includes among the participants the states from whose territory or facility a space object is launched. The language of Article V provides little guidance with respect to the definition of a joint launching. For example, the question may be raised whether a state is a participant or a joint launching state if.

1. it is responsible for a relatively minor experiment package on board the space object;
2. its nationals manufacture or supply a minor component part; or
3. it is represented at launch by a technical observer.[20]

Finally, Article VI exonerates a launching state from absolute liability if it can establish that the damage resulted either wholly or partially from gross negligence or from an act or omission done with intent to cause damage which may be ascribed to the claimant state or to the natural or juridical persons which it represents. However, Paragraph 2 prevents exoneration where the damage resulted from activities of the launching state which were not conducted in accordance with the applicable principles of international law, especially the United Nations Charter and the Outer Space Treaty.

Two main problems of construction are raised by the terms of Article VI. First, the meaning of "gross negligence" is left undefined and is subject to dispute. Second, the question may be raised whether exoneration from absolute liability under Article VI(1) relieves the launching state from all liability. Some contend that Article VI(1) should be construed to relieve liability only to the extent that the conduct of the nationals of the claimant state caused the damage in question.[21]

B. Articles VIII - XX

Articles VIII through XX of the Liability Convention establish procedural guidelines for the presentation and

prosecution of claims. Article VIII identifies the states which are entitled to advance claims. Paragraph 1 authorizes the state which has actually sustained damage or whose nationals have suffered personal injury or property damage to present a claim for compensation. However, under Paragraph 3 if the state of nationality has not presented a claim, the state in whose territory the damage occurred may demand compensation, regardless of the nationality of the entity actually sustaining damage. If neither of the first two governments has sponsored or stated its intention to sponsor a claim, any state may present a demand for compensation for damage actually suffered by any of its permanent residents.

Article VIII has the effect of expanding the traditional rule that only the state of nationality is authorized to present a claim for damages.[22] However, the number of authorized claimants presents three main problems. First, Article VIII does not define the period of time within which the state of nationality or the state within whose territory the damage occurred must act to preserve its right. Second, Article VIII(2) does not require the latter to ascertain whether the state of nationality intends to present a claim.[23] Finally, the text of this article does not solve the question of authorized representation if under Paragraphs 2 or 3 a claim is properly presented and the state of nationality presents a subsequent claim. This question is particularly important to space industrialists, in light of the general rule that a state

presenting an international claim is not obligated to pay any compensation to the party actually injured.[24] If the state of nationality were permitted to recover compensation from the launching state, the injured party could reasonably expect that political and economic considerations would motivate the state of nationality to convey all or part of the compensation to its injured nationals. However, if the state in whose territory the injury actually occurred recovers, the injured party would have a diminished prospect of recovery, since it would possess a limited ability to exert effective political pressure. This concern is diminished somewhat by the terms of Article XI(2) which permits the injured party to seek redress in the courts or administrative tribunals of the launching state.

Article IX places the claims procedure on a diplomatic basis, subject to the provision for judicial or administrative relief contained in Article XI(2). Time limits for the presentation of claims are established in Article X which has the effect of establishing a one-year statute of limitation measured from the date of occurrence or the date of identification of the launching state, or the date on which the claimant state could reasonably be expected to have discovered those facts through the exercise of due diligence. However, in cases in which the full extent of the damage is not immediately determinable, the claimant state is entitled to revise the claim and submit additional documentation until one year after the full extent of the damage is known.

Article XI(1) introduces an innovation into the practice of states regarding international claims. Traditional rules require the claimant to exhaust available local remedies prior to the presentation of the claim through diplomatic channels.[25] However, for the types of injuries covered by the convention, Article XI(1) expressly nullifies the traditional rule with respect to local remedies available either to the claimant state or to the natural or juridical entities represented by the state under authority granted by Article VIII.

As noted above, as an alternative to diplomatic claims procedures, Article XI(2) preserves the right of a state or the natural or juridical persons it represents to pursue administrative or judicial remedies available under the law of the launching state. Thus, Paragraph 2 enables the injured party to proceed directly against the party directly responsible for the injury, potentially including parts manufacturers and system operators. Depending on the law of the launching state, relief may also be available against the government of the launching state. However, recovery under this direct approach is likely to be limited, first, to the damage actually caused by government officers and employees, and second, by the problems inherent in judicial and administrative actions between sovereign and non-sovereign parties.

A second problem posed by Article XI(2) is that as a practical matter the decision to pursue a remedy under Paragraph 2 is likely to amount to waiver of a claim through diplomatic

channels, since the second sentence of Paragraph 2 denies a claimant state the right to present through diplomatic channels a demand for compensation which relates to the same damage or injury which serves as the basis for judicial or administrative action under the law of the launching state. That provision raises two questions. The prohibition on simultaneous pursuit of parallel remedies combined with the consideration that the time normally required to litigate a substantial claim is likely to exceed one year would probably prevent presentation of a subsequent claim through diplomatic channels. Hence, if the statute of limitations for judicial or administrative actions exceeds one year, the injured party should consider delaying initiation of such actions pending determination of diplomatic claims. The latter possibility raises the questions, first, whether the judicial or administrative claim would be barred by res judicata or related principles, and second, whether the time limit for presentation of a claim established in Article X applies to judicial and administrative actions as well as to diplomatic claims. Although the language of Article X does not directly answer the latter question, the choice of words and Article X's relationship to Articles VIII and IX suggests that its impact is limited to diplimatic claims.

The measure of compensation to be paid to the claimant state is to be determined under Article XII

> in accordance with international law and the principles of justice and equity in order to provide such reparation . . . as will restore the person, natural or juridical, State or international organization on whose behalf the claim is presented to the condition which could have existed if the damage had not occurred.

From the perspective of space industrialists, the standard is unsatisfactory, due to its vagueness. Particularly problematic is the question of availability of interest from the time the damage occurred, lost profits and the costs of pursuing the claim. Article XII is supplemented by Article XIII which requires the launching state to pay any compensation due in the currency of the claimant state, unless the latter requests payment in the currency of the launching state, or unless the two states agree on some other form of compensation.

Articles XIV-XX provide for the establishment of a claims commission to settle claims which are presented but are not resolved through diplomatic procedures. In general these procedures do not directly affect the interests of entities contemplating industrialization of outer space. Nonetheless, three provisions should be noted. First, Article XIV requires the claimant and launching states to form a claims commission if a claim presented through diplomatic channels in accordance with the provisions of Article IX is not resolved within one year from the date the claim is presented. Second, the claims commission is authorized under Article XVIII to determine the merits of the claimant to fix the amount of compensation, if any, to be paid. Finally, Article XIX(2) provides:

> The decision of the Commission shall be final and binding if the parties have so agreed· otherwise the Commission shall render a final and recommendatory award, which the parties shall consider in good faith. The Commission shall state the reasons for its decision or award.

The fact that decisions of the commission are binding only if the states forming the commission so agree further weakens the protections offered by the convention to potential space entrepreneurs.

III. INTERNATIONAL TELECOMMUNICATION CONVENTION AND ITU RADIO REGULATIONS

The third major international instrument which is likely to influence industrial development in outer space is the International Telecommunication Convention[1] and the Radio Regulations promulgated by the International Telecommunication Union (ITU) under authority granted in the convention. The principles embodied in the Convention and the Radio Regulations are likely to be most important for space industrial installations which require utilization of the geostationary orbit.[2]

As suggested above,[3] Articles I, II and IX of the Outer Space Treaty establish general principles governing the utilization of the geostationary orbit for all purposes, including space industrialization. However, to date, international debate regarding the practical application of those provisions to the task of managing the geostationary orbit has occurred primarily at the World Administrative Radio Conferences convened by the International Telecommunication Union for the purpose of regulating global telecommunications activity and accommodating conflicting uses of the electromagnetic spectrum. During the past fifteen years the ITU has also developed an interest in the management of the geostationary orbit.

That interest is based both on the special characteristics of the orbit which make it particularly valuable for communications satellite applications and on the character of the geostationary orbit as a limited natural resource. Some experts

argue that if mutual interference is to be avoided, the number of satellites in geostationary orbit must be limited to 180.[4] Others contend that the spacing of satellites could be diminished, leaving only the necessary safety margin to ensure avoidance of collision, with the result that the capacity of the orbit could be increased to nearly 1800 satellites.[5] However, in order to ensure avoidance of mutual interference under the present state of communications satellite technology, the spacing must be increased beyond the minimum necessary to prevent collision. Thus, although the maximum capacity is dependent on a number of technical variables, including frequency staggering, signal polarization, signal format, location of earth stations, and transmission power, and hence cannot be precisely calculated, the geostationary orbit must be considered a limited resource.[6]

The 1959 ITU Radio Regulations which govern the use of the electromagnetic spectrum have been periodically revised to respond to developments in satellite communications. In 1963 the ITU convened the Extraordinary Administrative Radio Conference in Geneva to allocate frequencies for use by satellites. Although the Radio Regulations were partially revised,[7] the conference did not alter the historical practice of permitting individual states to assign transmission frequencies unilaterally.[8] Thus, the traditional "first come, first served" approach was extended into the realm of satellite communication where it applies both to the allocation frequencies and to occupation of orbital "parking slots" by communications

satellites.[9] Since that approach gives an obvious advantage to those technologically advanced states which are presently capable of establishing geostationary satellite systems, less developed states began to exert pressure to preserve future interests in use of the orbit against saturation by more developed countries.[10]

During the following eight years, utilization of the orbit grew dramatically, causing increased concern among non-space powers. Against this background, the ITU convened the 1971 World Administrative Radio Conference for Space Telecommunications (WARC-ST) in Geneva. In opposition to proposals that the ITU should allocate not only frequencies but orbital slots as well, the United States argued that regulation of the orbit would inhibit its development as a natural resource[11] The strength of the opposition and other complications resulted in the general preservation of the status quo.[12] Nonetheless, some progress was made toward the accommodation of the conflicting interests of states at various stages of economic and technological development. Article 9A of the Radio Regulations was revised to establish a mechanism for coordinating use of the geostationary orbit.[13] Section I requires a government which intends to establish a satellite system to convey to the International Frequency Registration Board (IFRB), the entity responsible for management of the international use of the electromagnetic spectrum,[14] within five years prior to commencement of service, information defined in Appendix 1B of the Radio Regulations relating to the characteristics of

the system's satellites and earth stations, including orbital information. In particular with respect to geostationary satellites, Section II requires any government considering the use of the orbit to coordinate the planned use -- prior to notification of the IFRB under Section I on commencement of service -- with any other government which has registered an assignment in the same band with the IFRB or which is engaged in or has completed coordination procedures under this section. To facilitate coordination the former is to supply the information defined in Appendix 1A of the Regulations The purpose of this coordination procedure is to promote resolution of potential conflicts prior to commencement of system construction.

Another element of the effort of delegates to the WARC-ST conference to resolve conflicts regarding management of the orbit is embodied in Resolution Spa 2-1, which reflected the concern of non-space powers regarding the management of the orbit. In part the resolution provides:

> The World Administrative Radio Conference for Space Telecommunications (Geneva, 1971),
>
> *considering*
>
> that all countries have equal rights in the use of both the radio frequencies allocated to various space radiocommunication services and the geostationary satellite orbit for these services,
>
> *taking into account*
>
> that the radio frequency spectrum and the geostationary satellite orbit are limited natural resources and should be most effectively and economically used,
>
> *having in mind*
>
> that the use of the allocated frequency bands and fixed positions in the geostationary satellite orbit by individual countries or groups of countries can start at various dates depending on requirements and readiness of technical facilities of countries,

> *resolves*
> 1. that the registration with the ITU of frequency assignments for space radiocommunication services and their use should not provide any permanent priority for any individual country or groups of countries and should not create an obstacle to the establishment of space systems by other countries . . . .

The linkage between the revised version of Article 9A and Resolution Spa 2-1 is embodied in Resolution Spa 2-2 which reiterated the importance of achieving the best possible use of the geostationary orbit and the frequency bands assigned to the broadcasting satellite service, and which called upon participating governments to establish and operate satellite broadcasting systems in accordance with plans established by general and regional conferences in which affected states are entitled to participate.[15] Although not binding on the parties to the International Telecommunication Convention,[16] the resolutions expressed a broadening consensus among participating delegations and emphasized the fact that the Radio Regulation does not provide permanent protection to spectrum and orbital assignments for space broadcasting services.[17] However, the resolutions did not allay the concern of non-space powers that present space activities will saturate the most desirable segments of the orbital arc.

The third phase of the ITU's consideration of the problem of allocating the geostationary orbit among potentially conflicting uses occurred at the Plenipotentiary Conference of the ITU which was held in September and October 1973 in Torremolinos. The basic purpose of the conference was to evaluate and, if necessary, revise the ITU's fundamental structure and functions.

In addition, the question of orbital slot allocation was included in the agenda [18] In that context the Israeli delegation proposed to modify the International Telecommunication Convention to authorize ITU allocation of both the frequency spectrum and geostationary orbital slots as a means of ensuring equitable access by all parties.[19] Although the Israeli proposal did not receive the support required for adoption, the Plenipotentiary Conference amended the listing of the duties to be performed by the IFRB contained in Article 10 of the Convention to add relatively undefined responsibilities relating to the geostationary orbit. In revised form Article 10(3) provides.

> The essential duties of the International Frequency Registration Board shall be.
>
> a) to effect an orderly recording of frequency assignments made by the different countries so as to establish, in accordance with the procedure provided for in the Radio Regulations and in accordance with any decision which may be taken by competent conferences of the Union, the date, purpose and technical characteristics of each of these assignments, with a view to ensuring formal international recognition thereof.
>
> aa) <u>to effect, in the same conditions and for the same purpose, an orderly recording of the positions assigned by countries to geostationary satellites</u>;
>
> b) to furnish advice to Members with a view to the operation of the maximum practicable number of radio channels in those portions of the spectrum where harmful interference may occur, and <u>with a view to the equitable, effective and economical use of the geostationary satellite orbit</u>,
>
> c) to perform any additional duties, concerned with the assignment and utilization of frequencies and <u>with the utilization of the geostationary satellite orbit</u>, in accordance with the procedures provided for in the Radio Regulations, and as prescribed by a competent conference of the Union, or by the Administrative Council with the consent of a majority of the Members of the Union, in preparation for or in pursuance of the decisions of such a conference . . . (emphasis added)

In essence, the IFRB was instructed to record use of orbital slots on the same basis as frequencies for space services.

Although the revised version of Article 10 authorized recording of orbital use, the basic "first come, first served" approach was not altered. However, in order to preserve the interests of non-space powers, the Plenipotentiary Conference also revised Article 33 to provide.

> Rational Use of the Radio Frequency Spectrum and of the Geostationary Satellite Orbit
>
> In using frequency bands for radio space services Members shall bear in mind that radio frequencies and the geostationary satellite orbit are limited natural resources, that they must be used efficiently and economically so that countries or groups of countries may have equitable access to both in conformity with the provisions of the Radio Regulations according to their needs and the technical facilities at their disposal.[20]

Read in combination, the revised version of Articles 10 and 33, which became effective January 1, 1975, lead to a series of conclusions regarding the status of management of the geostationary orbit·

1. Countries are entitled to utilize the geostationary orbit and to record such use with the IFRB:
2. At least during the period of active use of an orbital slot, the system operator is protected against harmful interference from subsequently established systems by the coordination requirements of Article 9A,
3. The system operator is not entitled to permanent utilization of any particular orbital slot, and

4. Governments operating geostationary satellites are required to conduct their operations in such a way as to permit equitable areas to orbital slots by other governments subsequently establishing communications systems based on the use of geostationary satellites.

At the 1977 World Administrative Radio Conference for the planning of the broadcasting-satellite service in the 12 GHz band (WARC-BS), principles to govern the management of the geostationary orbit were discussed. During the debates,[21] Columbia and other equatorial states raised the question of national sovereignty over the geostationary orbit. At the 1975 session of the First Committee of the General Assembly, Colombia had asserted that the geostationary orbit is a natural resource over which equatorial states are entitled to exercise sovereign rights in relation to the segments of the arc located over their respective territories.[22] Similar contentions had been incorporated in the Bogota Declaration of December 3, 1976.[23] The states which supported that document raised the question at WARC-BS and stated their opposition to allocation of orbital slots in an effort to promote international recognition of national jurisdictional control. Recognition of that approach would permit the equatorial states to control access to the orbit, most likely on a licensing basis. However, conflicts with the "free use" principle of Article I(2) and the Article II prohibition against

appropriation as well as the low level of support from non-equatorial states suggest that the establishment of an international consensus on this approach is unlikely.

The remaining delegations divided their support between development of an a priori plan and evolutionary planning for orbital slot and frequency allocation. Under the first approach, a comprehensive plan covering all aspects of the allocation question would be developed in an attempt to accommodate to the maximum possible extent the whole set of needs foreseen by the period covered by the plan.[24] In contrast, under evolutionary planning, system design and deployment would be undertaken within limits imposed by a series of general sharing principles and would be based as prior consultations with other governments whose existing systems could be affected by the establishment of new systems. Under that approach, no advance assignments of orbital slots, frequencies and signal polarizations are made, permitting actual use to benefit from advancing technology.[25]

The a priori approach enjoyed substantial support from a significant number of non-equatorial states in Regions I and III. The United States led another bloc of states including Canada and Brazil which opposed a priori planning supporting instead various forms of evolutionary allocation for Region II. When the WARC-BS ended, no a priori plan was approved for Region II, but a conference of Region II countries, including North and South America and the Caribbean states, was scheduled for 1982, at which a "detailed plan" is to be considered.[26] Thus, the conference did not significantly alter the existing regime with

respect to use of the geostationary orbit by the United States, Canada and Latin America. However, technological advances are likely to result in increased pressure to preserve rights of access for states which do not yet possess the capability to operate satellite systems.

In June and July 1976, the Administrative Council of the ITU met in Geneva to determine, among other things, the agenda for the 1979 World Administrative Radio Conference. In its present form,[27] the agenda calls for the review and, if necessary, revision of Articles 9 and 9A relating to the coordination, notification and recording of frequency assignments.[28] As noted above, Article 9A establishes procedures for coordinating use of the geostationary orbit.[29]

In the context of discussions of Article 9A, the issue of allocating orbital slots is likely to be raised. Participating delegations are expected to align themselves along the lines drawn at the WARC-BS. Equatorial states will continue to press their claims that the geostationary orbit is a natural resource subject to the sovereign control of individual countries which lie along the equator. The non-equatorial developing countries and those which are considered developed but which do not yet possess the capability to operate sophisticated satellite systems can be expected to press for adoption of a comprehensive frequency and orbital slot allocation plan which would ensure future access to segments of the geostationary orbit suitable for national or regional use. The United States and other space powers are likely to continue their support of evolutionary

planning in order both to ensure maximum use of the orbit and to incorporate technological advances into the allocation scheme as rapidly as they occur.

The debate will be given a sense of urgency by intervening communications satellite experimentation and the evolution of planning for operational domestic, regional and global satellite networks. Canadian and American experimentation using the ATS-6 and CTS systems will focus on applications of geostationary, high-power broadband satellites transmissions in conjunction with small terrestrial receiving terminals.[30] In addition, experimental activities by the European Space Agency (ESA) and the Japanese National Space Development Agency (NSDA) are expected to demonstrate the utility of new applications.[31]

These experimental activities will provide the basis for expanded operational use of geostationary communications satellites. Significant expansion of the Intelsat network and deployment of new Intelsat V satellites are projected.[32] On the regional level, the Arab League's Telecommunications Union is considering establishing a system based on geostationary satellites for the provision of broadcast and telephone services to each member country.[33] Expanded domestic systems are either under development or in the planning phase in the United States, Canada, Indonesia, Iran and Japan. In addition, a number of countries, including Algeria, Zaire, Brazil, Nigeria and Norway have leased or are considering leasing transponders from Intelsat for dedicated use in domestic systems.[34]

Increases in existing and planned use of the geostationary orbit for communications and other purposes will provide impetus for the 1979 WARC debate regarding allocation of the geostationary orbit. Because of the key role played in the existing law of outer space by the "free use" principle of Article I(2) and the non-appropriation principle of Article II, and in light of the potential economic and social value of the proposed satellite applications based on the use of the geostationary orbit, the claims of equatorial states to sovereign control over large segments of the orbit are unlikely to receive broad international recognition. Thus, the main struggle is likely to take place between comprehensive advance allocation of frequency and orbital slots and allocation according to actual use, taking into account existing systems and advancing technology.

Current positions and trends of discussion indicate that although substantial discussion of the problem will occur at the 1979 WARC, no definitive solution will be reached, because of the strength of the competing interests involved. Proposals for both *a priori* and evolutionary planning are likely to be referred for consideration to regional conferences. After consideration there, the resulting recommendations will probably be re-examined at a general WARC in the mid-1980s. Debates at the 1979 WARC and subsequent conferences are likely to reveal a trend toward the assignment within each region of orbital segments dedicated to individual communications services. Within each segment, each country would be assured equitable access to orbital slots, but no specific frequency or orbital

slot allocations would be made in advance of actual use. Despite a trend toward that approach, complicating factors including non-communications applications such as satellite power generation are likely to delay establishment of an effective compromise among competing interests.

Thus, the impact of the 1979 WARC on the development and establishment of satellite power systems is likely to center on identification, first, of the problems of coordinating potential uses of the geostationary orbit to avoid mutual harmful interference, and second, of the competing interests of equatorial, developing and developed countries in the use of the orbit. In particular, since satellite power systems are not likely to be operational prior to 1995 and therefore are dependent on long-term orbital management activities, the progress projected for the 1979 WARC is likely to emphasize the importance of preliminary planning and evaluation of future orbital requirements for satellite power systems in order to ensure that future conferences take into account both the need to establish such systems and, if established, their projected orbital requirements.

PART III

The treaties and conventions discussed in Part III provide the general legal framework within which the industrialization of outer space is likely to evolve. As technological advances make establishment of experimental and operational systems imminent, various members of the international community will initiate efforts to elaborate the general instruments discussed above by establishing more specific guidelines to govern particular activities. Thus, for example, planning and experimentation relating to direct broadcast and earth resources satellites have promoted extensive consideration of relevant technical, organizational and legal guidelines by the United Nations Committee on the Peaceful Uses of Outer Space (CPUOS) and its subcommittees. To the extent that the concept of space industrialization encompasses the direct television broadcasting via satellite, remote sensing and closely related activities, the CPUOS debates provide a basis for predictions regarding the structure of international space law at the time such systems become fully operational. The CPUOS debates also indicate trends which are likely to influence future negotiations relating to uses of outer space which are not yet under consideration in CPUOS, including satellite power systems and space manufacturing.

In addition to trends indicated by CPUOS activities, other evidence regarding the future of international space law

can be derived from developments in other areas of international law. One example is the analogy which can be drawn to the positions taken by various delegations on legal and institutional issues at the present series of United Nations Conferences on the Law of the Sea as reflected in the negotiating texts. Another example is the evolving concept of "the common heritage of mankind" which has received some measure of support in negotiations relating to the management of both the seas and outer space. Further guidance on questions relating to potential organizational configurations for entities engaged in space industrialization can be derived from current trends as evidenced by the practice of Intelsat, Inmarsat and Aerosat.

The purpose of Part III is to examine the most important of these trends:

1. direct broadcast satellites;
2. earth resources satellites; and
3. the draft moon treaty.

I. IMPLICATIONS OF THE COPUOS DEBATES ON DIRECT SATELLITE BROADCASTING FOR SPACE INDUSTRIALIZATION

NASA research and development activities utilizing the ATS and CTS systems have demonstrated the technical feasibility of direct broadcast satellites capable of transmitting program carrying signals directly to small-scale ground receivers, bypassing the complex terrestrial redistribution networks presently employed by existing systems.[1]

Direct broadcasting from satellites promises a number of benefits, including more efficient and extensive program dissemination on a national level both for educational and entertainment purposes and for increased interchange of ideas and information between cultures. Perhaps the most important of these is the potential for improving the quality of education. In all of the developing countries, and even in some of those considered developed, a shortage of well-qualified teachers has hindered national development, setting in motion a search for means to overcome the shortage. Educational television has been used successfully in many parts of the world to distribute over a wide area resources previously available only in isolated special teaching facilities. In a large number of countries, however, the absence of a well-developed, in-place terrestrial distribution system for educational programming, compounded by the difficulty of installation due to high costs, difficult terrain or a widely dispersed population, has prevented full realization of television's

educational potential. Direct satellite broadcasting technology is capable of overcoming these barriers, provided that certain economic and technical obstacles are overcome.

Along with its promise of increased interchange among peoples, direct broadcasting has also created concern among potential "receiving states" that the new technology will be exploited for purposes of propaganda or for cultural or economic imperialism. As early as 1963 that concern generated demands that a restrictive international legal regime be imposed on the use of direct broadcasting to prevent potential misuses. The significant initiatives in that regard have centered in the United Nations, taking place in a variety of agencies, including CPUOS, the ITU and UNESCO.

A. Main Positions

During the United Nations debate, three main positions have emerged. After a short initial period at the opposite pole, the Soviet Union has led Argentina, Brazil, Egypt, France and the Eastern European bloc in expressing concern over the potential for satellite transmission of politically subversive or culturally disruptive broadcasts across national boundaries without the prior consent of the receiving state. A number of less developed states have echoed the Soviet concern over propaganda. Morocco, Iran, Sierra Leone, and India, among other Third World states, have been especially concerned about cultural imperialism and the possibility that commercial advertising by the industrial powers would disrupt the social

fabric of developing nations. Some Third World nations have suggested that any television program displaying consumer-oriented societies in a favorable light would create a demand for consumer goods among their own citizens which could delay or perhaps even thwart national plans for social and economic development.[2] The key elements upon which these states would ultimately base an international institutional response are the principles of national sovereignty and the need to protect established cultures against intrusion from abroad.

Opposition to the restrictive regulatory approach taken by the Soviet Union has been led by the United States, which has argued, first, that any regulation was premature, since no one could determine with any degree of certainty either the configuration of future direct broadcast systems or the nature of the political, economic and legal problems likely to arise when such systems finally become operational, and second, that an excessively restrictive policy could stifle the initiatives necessary to develop and implement direct broadcast technology. The third tenet of the United States' position has been the contention that a regime of prior consent and program control would violate both the First Amendment and the principle of the free flow of information contained in the Declaration of Human Rights, and would, therefore, be unacceptable as a matter of constitutional policy.

Sweden and Canada have taken an intermediate position, recognizing the need to incorporate both the free flow of

information and the protection of national sovereignty and cultural diversity into any viable regulatory scheme. To achieve that goal, the two states have advocated a regime based on international cooperation expressed in a prior agreement between the broadcasting and receiving states. Under the Swedish-Canadian proposal, program content would be determined by the bilateral prior consent agreement rather than by a global agreement as proposed by the Soviets.

The current series of CPUOS negotiations began in 1969 when the Working Group on Direct Broadcast Satellites was convened in New York pursuant to General Assembly Resolution 2453 B (XXIII).[3] After the Working Group held five sessions, the main debate regarding appropriate governing principles shifted to the Legal Sub-Committee in 1974, where some progress has been made toward the establishment of an international consensus. The basic foundations of the debate were embodied in proposals submitted by the Soviet Union, the United States and jointly by Sweden and Canada.

1. *The 1972 Soviet Draft Convention*

Concerned about the American progress with communications satellite technology, the Soviet Union unexpectedly introduced its restrictive Draft Convention on Principles Governing the Use by States of Artificial Earth Satellites for Direct Television Broadcasting to the General Assembly on 8 August 1972.[4] In a letter addressed to the Secretary-General, Soviet Foreign Minister Andrei Gromyko requested that the twenty-seventh

session of the General Assembly examine the feasibility of an international agreement for satellite broadcast regulation and that the Soviet proposal be included on the agenda.[5] The Soviet Union intended its draft to provide the foundation for a universally binding treaty approved by the CPUOS Legal Sub-Committee.

As submitted, the Soviet draft contained nearly all of the restrictive principles proposed during the previous meetings of the Working Group, including a strict provision permitting direct satellite broadcasting to foreign states "only with the express consent of the latter."[6] Article IV provided that any party to the proposed convention would undertake to exclude from programming transmitted via satellite "any material publicizing ideas of war, militarism, nazism, national and racial hatred and enmity between peoples, as well as material which is immoral or instigating in nature or is otherwise aimed at interfering in the domestic affairs or foreign policy of other states." Article VI elaborated the general statements of Article IV, listing specific categories of satellite broadcasting which would be illegal:

> (a) Broadcasts detrimental to the maintenance of international peace and security;
>
> (b) Broadcasts representing interference in intra-state conflicts of any kind;
>
> (c) Broadcasts involving an encroachment on fundamental human rights, on the dignity and worth of the human person and on the fundamental freedoms for all without distinction as to race, sex, language or religion;

(d) Broadcasts propagandizing violence, horrors, pornography, and the use of narcotics;

(e) Broadcasts undermining the foundations of the local civilization, culture, way of life, traditions or language;

(f) Broadcasts which misinform the public in these or other matters.

The ban on specific categories of program content was supported by Article XII, which would have denied any party to the convention the right to enter into any subsequent international agreement which conflicted with the convention. Thus, the proposed program content limitations were apparently intended to apply even if the broadcasting and receiving states had agreed to waive one or more of the limitations. Consequently, under the Soviet draft, any third state which considered the programming exchanged between the broadcasting and receiving state--even if pursuant to an agreement between the two--to fall within the proscribed categories, could invoke the remedial procedures foreseen in the Soviet draft, even if there were no possibility that the third state's citizens would receive the allegedly objectionable transmissions. In addition, the proposal also forbade advertising, except "on the basis of specific agreements specially concluded between those states concerned."[7]

The foundation for the remedial process was laid by Article VI, which imposed international liability of states against a broadcasting state where programming contained proscribed materials. Article VII extended the liability of

the broadcasting state to include any act of illegal broadcasting by one of its nationals, whether or not the broadcast was actually transmitted by a government agency. The imposition of international liability presumably made available to the objecting state all of the normal remedial procedures provided by international law. Article IX, however, also permitted the target state to "employ the means at its disposal" to counteract the illegal irradiation of its territory by a foreign state.[8] The convention did not state explicitly whether retaliatory military action against the satellite would be permissible in such cases. However, that interpretation was given credence by language contained in Foreign Minister Gromyko's letter conveying the draft convention to the Secretary-General.

> States may utilize the means at their disposal to counteract illegal direct broadcasting of which they are the object, not only in their own territory but also in outer space and other areas beyond the limits of national jurisdiction of any state.[9]

Gromyko's statement leaves open a number of undesirable responses by the target state, including the destruction of the satellite in space. Eventually, however, the Soviets indicated that only "lawful" measures would be authorized under the convention.[10]

The Secretary-General referred the Soviet draft to the Committee on the Peaceful Uses of Outer Space, which in turn approved consideration of direct broadcast issues by the Working Group at its fourth session.[11]

At the fifth session of the Working Group, the Soviet Union also took a slightly moderated position, substituting a

draft declaration of principles for the draft convention.[12] The substantive provisions were essentially identical to those of the 1972 draft convention, with two exceptions. The first exception was the draft declaration's omission of the listing of prescribed categories of program content in Article VI of the draft convention.[13] Although the specific listing is omitted, the general prescriptions of programs promoting militarism, racial hatred and cultural subversion contained in Article IV of the convention are retained in Article IV of the draft declaration, leaving the scope or effect of the limits on program content substantially unaffected.

A second difference between the two drafts relates to the issue of spillover. Under Article VIII(2) of the 1972 draft convention, any state believing itself subjected to unintentional radiation would have been entitled only to request consultations with the broadcasting state. The draft declaration would have authorized the offended state to compel immediate consultations regarding program content if the unintentional spillover were receivable in its territory by ordinary receivers or receivers augmented by simple devices.[14] Both drafts would have proscribed any intentional broadcast unless authorized by prior agreement between the broadcasting and receiving states.[15]

The final difference between the two Soviet drafts is found in the remedial provisions. Article IX(1) of the 1972 draft convention would have permitted any party to the convention to:

> employ the means at its disposal to counteract illegal television broadcasting of which it is the object, not only in its own territory but also in outer space and other areas beyond the limits of the national jurisdiction of any State,

leaving open the possibility that an offended state might consider itself entitled to destroy the satellite relaying allegedly unlawful programming.[16] The counterpart to Article IX(1) in the draft declaration limits the response of the complainant state to those "measures which are recognized as legal under international law.[17]

Despite the near identity between the operative provisions of the 1972 draft convention and the 1974 draft declaration, the former represents a moderation of the Soviet position. By accepting a non-binding declaration, rather than a treaty, as the appropriate mode for expressing an international consensus, the Soviets moved toward compromise with the American and Swedish-Canadian positions.

2. *The Swedish-Canadian Draft Principles*

Also considered at the fourth session of the Working Group in 1973 was a draft declaration submitted jointly by the Swedish and Canadian delegations. Officially entitled The Draft Principles Governing Direct Television Broadcasting by Satellite,[18] the Swedish-Canadian proposal attempted to reconcile the free flow of information with national sovereignty through the application of the basic principles of cooperation and participation. Like the Soviet draft convention, the joint Swedish-Canadian proposal would have required the broadcaster to secure the consent of the recipient state·

> Direct television broadcasting by satellite to any foreign State shall be undertaken only with the consent of that State. The consenting State shall have the right to participate in activities which involve coverage of territory under its jurisdiction and control. This participation shall be governed by appropriate international arrangements between the States involved . . . .[19]

The draft declaration did not, however, include an explicit program code. Instead, Article VIII would have mandated participation of the recipient state in "the scheduling, content, production and exchange of programmes and all other aspects, including if appropriate, the training of technical and programme personnel."[20] The combination of prior consent and participation provisions would have nullified the potential for offensive program content, while permitting the participatory states to tailor programming to their respective needs. Although the prior consent provision was comparable to that proposed in the Soviet draft, the Swedish-Canadian draft would have permitted interested states to consent to any type of programming, while the Soviets advocated the establishment of prohibitions against specific categories of content.[21]

The Swedish-Canadian draft declaration also would have distinguished between technically unavoidable spillover and the intentional transmission of television signals to a foreign country. While the prior consent clause would not have operated in the case of unavoidable spillover, the draft declaration specified that the consent and participation provisions were to be applicable in situations·

> (a) where coverage of the territory of a foreign State entails radiation of the satellite signal beyond the limits considered technically unavoidable under the Radio Regulations of the International Telecommunication Union; or
>
> (b) where notwithstanding the technical unavoidability of spillover to the territory of a foreign State, the satellite broadcast is aimed specifically at an audience in that State within the area of spillover.[22]

If any state concluded that another was violating the principles set forth above, the joint document would have authorized the former to call upon the latter to enter into consultations regarding the alleged violations. If the consultations did not reach a mutually acceptable settlement, the aggrieved state would have been entitled to seek a settlement through the established procedures for the resolution of disputes "such as conciliation, mediation, arbitration or judicial settlement."[23]

The Swedish-Canadian draft appears to be a useful compromise between the Soviet draft convention and the arguments presented orally by the American delegation. The proposal contained an explicit prior consent provision, similar to that sought by the Soviets, but it omitted the controls on program content so vehemently opposed by the American delegation. Nonetheless, the ommission was potentially compatible with the Soviet position, since the shared control of specific programming could serve as an effective substitute. The joint proposal would also have assured American broadcasters that they would not be forbidden to transmit commercial programming to other nations on the basis of objections based on content, provided

they were able to persuade the receiving state to consent to receive direct broadcasting. In addition, a state irradiated by spillover resulting from consented transmission between two other states could not interfere with the transmissions on the ground that it had not also consented, if the spillover were technically unavoidable and not specifically directed at the complaining state. Finally, the fact that the document did not authorize censorship or contain a list of proscribed programs could have eased the American constitutional objections to international broadcast regulation.

3. *The United States Draft Principles*

During the first four sessions of the Working Group, the United States consistently argued that any international declaration or treaty on direct broadcasting would impede development and operational implementation of the technology. However, in response to the Soviet and Swedish-Canadian initiatives, the United States delegation submitted its own draft declaration of principles to the fifth session of the Working Group. Framed in general terms, the American Draft Principles on Direct Broadcast Satellites[24] did not attempt to enumerate illegal broadcast applications. In contrast to the Soviet document, the American proposal took a positive approach, encouraging rather than limiting the use of direct broadcast satellites. The draft recognized the need for direct broadcasting to develop within the limits imposed by the ITU technical parameters and procedures, as well as by

international law, including the United Nations Charter and the Outer Space Treaty.[25] In its proposal the United States also included the principle that direct broadcasting should be carried out in a manner both compatible with the maintenance of international peace and sensitive to the differences among cultures.[26] Within that framework the American delegation proposed that the evolving technology be applied so as to "encourage and expand the free and open exchange of information and ideas."[27] Implementation of the fundamental principle of the free flow of information was to be achieved by promoting access of every state to both transmitting and receiving facilities insofar as technical obstacles could be overcome.[28] The organizational and programming barriers were to be overcome through cooperative efforts of international organizations and regional broadcasting associations,[29] with any disputes to be resolved by established procedures.[30] Finally, the draft principles introduced by the United States delegation called upon the United Nations and its member states to "review the questions of the use of satellites for international direct television broadcasting if practical experience indicates the need for such a review.[31]

From the beginning of the direct broadcast debate, the basic tenets of the American position had been the free flow of information, deferral of regulation until concrete problems have arisen, and application of the evolving technology through regional cooperation. Thus, in one sense, the proposed principles

simply formalized the previously established position. Nonetheless, the American draft represented an important step toward compromise. Until the Working Group's fifth session, the United States had opposed any attempt to establish limitations, whether binding or not, on direct broadcasting. By introducing its own set of draft principles, the United States accepted the proposition that the establishment of such non-binding principles would facilitate the development of the technology. The American proposal also recognized for the first time the need to include a provision for broad access in order to ensure the two-way flow envisioned in the principle of free flow of information. Although conditioned upon the ability to overcome unspecified "practical difficulites," the shared access principle represented another step toward resolution of the direct broadcast controversy.

B. Present Status of the Direct Broadcast Debate

Since 1974 the CPUOS Legal Sub-Committee has made some progress toward a consensus on direct broadcast issues. The following subsections are intended to describe the current status of the debates on specific key issues.

1. Purposes and Objectives

At the final session of the Working Group in 1974, the delegations agreed that direct broadcasting should have as its goals the promotion of international peace, the facilitation of global economic and social development and the furtherance of intercultural understanding.[32] The report concluded that all direct broadcasting activities should be conducted exclusively in a manner compatible with those goals.[33] However, at the fourteenth session of the Legal Sub-Committee, one group of delegates argued that that policy should be made mandatory, while others contended that the principle in question should remain a non-obligatory statement of a general policy.[34] During the fifteenth session, the delegations agreed on the latter approach.[35]

2. Applicability of International Law

The report of the fourteenth session of the subcommittee recognized that the United Nations Charter, the Outer Space Treaty, and the International Telecommunication Convention with its Radio Regulations had established general limits within which direct broadcasting would have to evolve.[36] Left unresolved, however, was the issue whether the draft

principle regarding the applicability of international law should state that direct broadcasting "should be" conducted in accordance with generally recognized rules or whether such a provision should impose on states the obligation to ensure the compliance of activities within their jurisdiction.[37] In addition, disagreement remained relating to the inclusion among the principles to be applied of the Universal Declaration of Human Rights, the International Covenant on Civil and Political Rights and the Declaration on Principles of International Law Concerning Friendly Relations and Cooperation Among States.[38]

Article III of the 1967 Outer Space Treaty appears to resolve the first question by obligating states who are parties to the treaty to conduct activities in outer space in accordance with international law.[39] Consequently, the obligation of states to comply with international law would not be diminished by omission of an express statement of the obligation. Thus, the decision of the subcommittee at its fifteenth session to endorse non-obligatory language does not seriously limit the legal impact of the draft declaration ultimately approved by CPUOS.[40]

Although the inclusion of general references to the Universal Declaration of Human Rights, the International Covenant on Civil and Political Rights, and the Declaration of Principles of International Law Concerning Friendly Relations and Cooperation Among States could be justified as an additional step toward the establishment both of a liberal regime for direct broadcasting which would facilitate educational application

and of customary rules regarding an international obligation to protect human rights, the practicalities of international negotiation in the present case seem to indicate that reference will be made only to those principles particularly relevant to the direct broadcast controversy, namely sovereignty, non-intervention, and the free flow of information. In order to facilitate establishment of a consensus, the subcommittee agreed in 1976 to substitute the phrase "the relevant provisions of . . . international instruments relating to friendly relations and co-operation among States and to human rights" in place of reference to specific instruments as previously proposed.[41]

3. *Rights and Benefits*

At the 1974 session of the Working Group, the participating delegations agreed that all states have an equal right to conduct or authorize direct broadcasting, and that all states are entitled to share in the benefits of the new technology, regardless of their degree of economic or scientific development.[42] The sharing of benefits thus foreseen was to include increasing opportunities for access to direct broadcast systems, based on specific agreements between the states concerned.[43] The basic consensus was not disturbed at the fourteenth session of the Legal Sub-Committee. Two sub-issues were, however, left unresolved.[44] First, some delegations advocated inclusion of a provision limiting direct broadcast activities to either governmental agencies or entities under government supervision. The inclusion of such a provision would be important to the

imposition of the international liability of states, and would therefore be an essential part of any regime designed to impose enforceable restrictions on program content. In all of its proposals, the Soviet Union has consistently sought to restrict direct broadcast activities to those entities controlled by their respective governments.[45] The United States has resisted such attempts in order to preserve the use of direct broadcast satellites for commercial programming. A second sub-issue arose regarding whether the right of equitable sharing in the benefits of direct broadcasting should be stated in obligatory or normative terms.[46] The subcommittee reached agreement at its 1976 session based on normative rather than obligatory language and on the deletion of express references to both supervision by governments and activities of individuals in outer space.[47]

4. International Cooperation

Strong recognition was given to the principle of international cooperation in the report of the fifth Working Group which described corporations as a "touchstone for the development and use of direct television broadcasting by satellite," and called upon states and international organizations, both governmental and non-governmental, to make every effort to enhance the capabilities of interested states to take advantage of direct broadcast technology.[48] Disagreement surfaced, however, in Legal Sub-Committee discussions regarding the application of the principle. Some delegations argued that direct broadcasting should be "based on" international cooperation, while

others advocated a regime in which direct broadcasting would "encourage" international cooperation.[49] The former position was consistent with the Swedish-Canadian position that international cooperation is essential to the realization of the educational potential of direct broadcasting, and that any set of governing principles should include a general prior consent provision. The position that direct broadcasting should "encourage" international cooperation expressed optimism regarding the educational value of direct broadcasting, but did not mention -- and presumably implicitly rejected -- the principle of prior consent. A compromise was reached at the fifteenth session of the Legal Sub-Committee which provided that direct broadcasting activities "should be based upon and encourage international co-operation."[50]

5. *State Responsibility*

A consensus was also obtained by the fourteenth session of the Legal Sub-Committee on the issue of state responsibility. The delegations at the fifth Working Group had agreed that states should bear international responsibility for direct broadcast activities as described in Article VI of the Outer Space Treaty.[51] Beyond that point disagreement on the issue surfaced. Some delegations argued that a state should bear international responsibility for all activities carried out by its nationals, regardless of whether the government had any authority under its constitution and laws. Other delegations rejected that argument, contending that the advantage of such a principle would have made states internationally liable

for the content of programming, a result which would have been unacceptable, especially for those states whose broadcasting entities were not subject to state control.[52]

The Legal Sub-Committee's drafting group resolved the disagreement and achieved a complete consensus regarding the question of state responsibility for direct broadcasting. Building on the foundation laid in the Outer Space Treaty, the draft principle accepted by the drafting group would impose responsibility on a state to ensure that all activities carried out by the state or under its jurisdiction are conducted in conformity with the whole set of draft principles.[53] Where direct broadcasting is carried out by an international organization, international responsibility would be borne both by the organization and by individual member states.[54] The essential elements of this agreement were not altered by the negotiations of the subcommittee's fifteenth session.[55]

6. *Duty and Right to Consult*

At the conclusion of the fourteenth session, no consensus was established on conflicting proposals regarding consultation between states with respect to direct broadcasting. The subcommittee reported two alternative proposals.[56] The first, supported mainly by potential "receiving" states, would have authorized a state which had reason to believe that its interests would be adversely affected by the direct broadcast activities of another state to request consultations with the broadcasting state. Under that approach, the broadcasting

state would have been required to enter into appropriate consultations without delay. The second alternative would have provided that any state which received a request for consultation regarding the direct broadcast activities of either should agree to commence such consultations without delay. At its fifteenth session, the subcommittee was able to reach agreement on a draft principle which parallels the second alternative described above.[57]

7. *Prior Consent*

The most difficult problem in the resolution of the direct broadcast controversy is the prior consent issue. At the close of the fifth session of the Working Group, the delegations remained divided into three main factions on the issue of prior consent, with the largest group favoring a legal regime granting the receiving state the right to deny its consent. That group argued that prior consent is consistent with the recognized right of each state to regulate its own communications system, and that a prior consent regime would avoid contravention of national broadcasting legislation.[58] The same faction also noted that the international community had already adopted the principle of prior consent when it adopted Article 7, §428A of the ITU Radio Regulations at the 1971 WARC-ST Conference.[59]

The second major group maintained that a clear distinction must be drawn between direct broadcasts intentionally transmitted to a foreign state and those received there as a result of

unavoidable spillover. In the first case, it was argued, prior consent should be required, because the principle of sovereignty gives each state the right to determine the form of its own political, economic and social systems, and therefore, the flow of information in its territory. Further, the inequality of opportunity to use direct broadcast technology strengthens the need for the protection which would be provided in a regime based on the concept of prior consent.[60]

The third major faction rejected the principle of prior consent altogether. These delegations argued that the right of prior consent would give the receiving state the authority to veto the transmission of any given program, thereby progressively undermining the principle of the free flow of information contrary to Article 19 of the Universal Declaration of Human Rights.[61] In addition, the imposition of a regime based on prior consent would inhibit full realization of direct broadcast technology, particularly for domestic systems, if the principle were applied to spillover.[62]

When the Legal Sub-Committee adjoined its fourteenth session, two main positions on the questions of prior consent remained. Proponents of the first position would prohibit direct broadcasts to any state unless that state had consented. If consent were given, the consenting state would have the right to participate in activities related to coverage of its territory. These consent and participation principles would not apply, however, where coverage of the foreign state resulted from technically unavoidable spillover as defined in

the ITU's Radio Regulations.[63] This position appears to correspond to the principles proposed by the Swedish and Canadian delegations to the fourth session of the Working Group.[64]

The second faction rejected the principle of prior consent, preferring instead a legal regime based on an undefined foundation of participation and cooperation.[65] The sole concrete element of cooperation approved by the second faction called upon the broadcasting state to consult with any receiving state on the request of the latter; however, the principle proposed would call for such consultations only with respect to restrictions imposed by the broadcasting state.[66]

During the 1976 session, the subcommittee was unable to report any progress. The reports of the fourteenth and fifteenth sessions contain identical sets of two alternative draft principles.[67]

8. *Spillover*

On the spillover issue, two main positions remained at the end of the Working Group's fifth session. The first group argued that since some spillover would be unavoidable, international principles should be elaborated to minimize international conflict. The other faction responded that technical developments might eliminate most problems created by spillover before individual reception in spillover areas will have become possible, thus obviating the need for a legal framework to resolve spillover disputes, particularly when technical procedures are already available under the auspices of the ITU.[68]

During the fourteenth session of the subcommittee, these positions crystallized somewhat. One position would require the broadcasting state to use "all technical means available to reduce, to the maximum extent practicable, the radiation over the territory of other countries" unless a prior agreement has been reached between the broadcasting and receiving states.[69] The other position would impose no requirement, but merely states that "all reasonable means should be used to reduce to a minimum any unintended radiation of the territory of other countries.[70] The latter position is consistent with the unlimited regime advocated by the United States, while the former would be an integral part of the prior consent regime proposed in the Swedish-Canadian drafts.

Some movement on the spillover issue was evident at the 1976 session. Previous session reports had incorporated a separate draft principle covering the spillover question.[71] During the fifteenth session, the separate spillover principle was deleted, and its substance was incorporated into the Alternative A of the proposed consent principle which would permit the receiving state to deny its consent to direct broadcasts.[72]

9. *Program Content*

Another key issue upon which the delegations were unable to establish a consensus was the question whether a set of international principles governing direct broadcasting should proscribe certain categories of program content. One group

of delegations argued that any such legal regime should combine a prior consent provision with an obligation to exclude from direct broadcasts programs which would threaten international peace, or which would promote war, militarism or social hatred, or which would undermine the foundations of the local civilization in any way.[73] The listing of programs to be banned resembled those contained in both the Soviet Union's 1972 draft convention and its 1974 draft declaration of principles.[74]

The second main position was similar to that advanced by the Swedish and Canadian delegations in previous sessions. The report of the fifth Working Group noted that some delegations had espoused the view that because of political, eononomic, social and cultural differences among states, the establishment of general principles or objective criteria for applying those principles would be very difficult, if not impossible. Further, it was argued that the inclusion of a principle of prior consent in a legal regime governing direct broadcasting would render restrictions on program content unnecessary, particularly if prior consent were complemented by a principle providing for participation of the receiving state.[75] The related view was expressed that, if the conduct of direct broadcasting was to be governed by the key principle of international cooperation, the inclusion of limitations effectively dictating program content would be inappropriate.[76]

During the Legal Sub-Committee debates, the American position merged with the Swedish-Canadian positions despite the conflict between the two on the question of prior consent. They proposed a principle calling for cooperation between states with respect to programming, program content, production and exchange of programs.[77] The fourteenth session report also notes a position, like that advocated consistently throughout the debates by the Soviet delegation, which would require states to exclude, regardless of other agreements, programming material which: 1) is detrimental to the maintenance of international peace; 2) publicized war, militarism, nazism or racial hatred, 3) is aimed at interfering in the domestic affairs of other states; or 4) undermines local culture in any way.[78]

During the Working Group debates regarding program content, the question of the permissibility of commercial programming or advertising arose. One faction supported the view that to the extent direct broadcast advertising created a demand in the receiving state for a particular product or in any other way generated conditions unfavorable to local industry, such programming would be undesirable and should be permitted only when expressly permitted by the receiving state.[79] Other states argued that no distinction should be drawn between advertising or commercial programming and any other category of program content.[80] The same positions were taken in the Legal Sub-Committee, with the result that a third disputed paragraph relating to program content would permit commercial

advertising only on the basis of prior agreements was incorporated in the session report.[81] During its 1976 session, the Legal Sub-Committee was unable to achieve progress on any aspect of the program content issue.[82]

10. Unlawful or Inadmissible Broadcasts

Closely related to the questions of prior consent and program content is a draft principle defining unlawful or inadmissible broadcasts. The first clause of the draft principle reported by the subcommittee is taken verbatim from Article VI of the draft principles presented to the fifth session of the Working Group by the Soviet delegation.[83] It provides that the international liability of states arises when either broadcasts are conducted without the express consent of the receiving state, or the broadcasts contain proscribed material, or when unintentional spillover is compounded by the broadcasting state's failure to enter into appropriate consultations with the receiving state.[84] The draft principle again drew from the Soviet proposals to the fifth Working Group when it authorized the receiving state to take any remedial measures recognized as legal under international law, without placing any priority upon negotiation, conciliation, arbitration or any of the other conflict resolution techniques preferred in the United Nations framework.[85] The states which opposed a direct broadcast regime based on program content limitations or prior consent, and consequently opposed outlawing any broadcast, rejected the draft principle *in toto*.

C. Prospects for Resolution of the Direct Broadcast Debates

When the direct broadcast debates began in 1963, they were not characterized by any special sense of urgency, since direct satellite broadcasting was neither technologically nor economically feasible in the foreseeable future. Since then the pressure to impose international controls to prevent potential abusive applications of the technology has increased sharply, primarily because of rapid, highly visible technological progress. NASA's experimental communication satellite programs, especially those using Application Technology Satellites (ATS) 1, 3, 5 and 6, and the operational successes of the Intelsat system have been particularly instrumental in overcoming technological barriers to direct broadcasting.[86] These experiments, combined with ambitious plans for more advanced experimentation, including the Indian-American SITE experiment and the Canadian-American CTS projects,[87] have motivated other countries to develop their own experimental or operational direct broadcast programs. At the Panel Meeting on Satellite Broadcast Systems for Education convened by CPUOS in Tokyo in April 1974, Japan announced that it would launch an experimental direct broadcast satellite in 1976,[88] and the Canadian and Brazilian delegations outlined plans to launch new domestic satellites to facilitate communications with their vast, remote hinterlands.[89] The French delegation offered free time on its Symphonie satellite to French-speaking African nations for educational programming,[90] and the European Space Research Organization announced plans

to establish an operational regional broadcast system by 1980.[91] Indonesia and Iran announced long-range preparations for educational television broadcasting via satellite, and Malaysia discussed its program to install 5,500 television and radio receivers and 2,000 electric generators in rural locations in order to improve its national educational system.[92] Although the Malaysians plan to rely on terrestrial distribution, they could become users of the Japanese satellite if costs prove to be sufficiently low.

Although the technological developments justify some international institutional response, the magnitude of the response seems disproportionately large in comparison to the imminence of potentially abusive application. Examination of the United Nations debates in direct broadcasting indicate the presence of three factors which have disrupted the processes which normally operate to establish an equilibrium between the forces which motivate technological development and those which support the creation of a regulatory institution to control abuses of the evolving technology.

The first of these is the failure to gauge accurately the relationship between specific experimental developments and the final technical configuration of a direct broadcast system which could be used for the purposes cited by proponents of a restrictive international legal regime. For example, the report of the first Working Group concluded that satellite transmission of television signals direct to unaugmented home receivers

was "not foreseen for the period 1970-1985," because present technology did not possess the means to transmit sufficiently powerful signals from satellites.[93] A number of governments erroneously interpreted this statement at future meetings of the Working Group to mean that telecasting directly to home installations would begin in 1985. Actually, the Working Group concluded that it would not be economically practical at any time before 1985, and perhaps not for some time after that.[94] National position papers submitted to later sessions of the Working Group based their analyses of the direct broadcast issues on the figures established during the first session. Not always accurate, the initial findings alarmed those nations concerned about propaganda and cultural imperialism, and may have added a note of urgency to their draft recommendations for the Working Group.

The second factor which has upset the normal equilibrium between technological and regulatory interests is the failure to assess realistically the limitations imposed on operational direct broadcasting by economic factors. In those more developed countries which have equipped themselves at great cost with an extensive terrestrial network for the distribution of television programming, transition to operational use of direct broadcast satellites would entail a radical realignment of the existing distribution patterns. In the United States, for example, transmission to home receivers would eliminate the need for local television stations, the common carrier land

lines connecting the local stations with the central program production facilities of the major television network organizations and cable television companies. Understandably, therefore, special interest groups have opposed the use of direct satellite broadcasting for national programming. Until a reliable economic analysis balancing the cost of the necessary realignment against the benefits of a direct broadcast network has been made, countries already possessing extensive television distribution networks are not likely to make a rapid transition to direct broadcasting.

For those reasons, the newly evolved technology will probably be most beneficial to the less developed countries. Such states generally have television broadcast facilities which serve only a few major cities. The construction of a comprehensive national network using conventional ground facilities is often economically unfeasible due to the present cost of hardware. The broadcast satellite can dramatically reduce these costs, especially when serving a large geographic area, difficult terrain, or a widely dispersed population.[95] In addition, a direct broadcast television network could become operational in a fraction of the time needed to construct a terrestrial system based on cable and microwave. Both of these factors recommend direct broadcasting to such nations as Brazil, India and Indonesia, where topographical features prevent the construction of truly national television systems. Once operational, a direct broadcast system could contribute

significantly to national development by facilitating national integration and improving the quality of the country's educational system.[96] In addition, users of direct broadcasting would probably reap other less direct benefits, including national economic development and access to foreign and international information resources.

Despite the relatively large range of advantages to be derived from direct broadcasting by those countries which do not yet have an extensive investment in terrestrial distribution systems, two main economic impediments still delay operational use by those countries. First, the cost of operating a direct broadcasting satellite system will still remain prohibitively expensive for individual less developed countries. At the United Nations Panel Meeting on Satellite Broadcasting Systems for Education, sponsored by CPUOS in Tokyo during February and March, 1974, the UNESCO representative presented an analysis of the financial requirements for satellite broadcasting, concluding that a viable system dedicated exclusively to educational television would require a population base of 100 million, assuming a gross national product of $200 per capita.[97] He further noted that other combinations of population and income could lead to viability, and that Iran, for example, could support a viable direct broadcast educational network with a population of thirty million, but a $1,000 per capita income.[98] By the same formula, if the annual per capita income were $100 -- the prevailing income level of many African

and Asian nations -- it would take a population of 200 million to support the satellite system. In these cases, therefore, the introduction of satellite television will depend upon cooperative arrangements on a regional basis,[99] on the use of multipurpose satellites capable of telephone and data switching, as well as television broadcasting, and on international financial and technical assistance.

The second economic factor is the shortage and high cost of ground receivers. At present, few Third World states have an adequate number of receivers to make any form of television broadcasting useful. In Asia, for example, only Japan and Singapore have enough television sets per capita to meet the minimum standard established by UNESCO as necessary if television is to serve as a useful educational tool.[100] The shortage of standard receivers is compounded by the fact that, at the current state-of-the-art, standard ground receivers require extensive augmentation to pick up the relatively weak signals transmitted by the satellites now in orbit. Augmentation increases the price of both individual receivers and the entire receiver network.

The report of the first Working Group estimated the cost of modifications to standard television receivers necessary for use as community receivers at $150, while the cost for modification of home receivers was estimated at $40 - $270.[101] The high cost of the receivers places them beyond the reach of the vast majority of individuals in nearly every country.

Hence, in the absence of substantial governmental assistance, economic factors will prevent the establishment of a network of receivers which is both capable of receiving signals broadcast directly from outer space and large enough to justify the enormous investment needed to establish the space segment of a direct broadcast network. The necessity of governmental assistance in establishing the receiver network facilitates governmental control and hence provides added protection against potentially abusive application.

The third factor disturbing the balance between technological and regulatory pressures is the failure of direct broadcasting antagonists to understand the extent to which existing technical regulations perform the functions of the proposed international legal principles. The most important examples are the ITU regulations which restrict satellite telecasting to frequencies several times higher than those normally used by standard television receivers,[102] and those which require the broadcaster to use all means technically available to reduce as much as possible the signal radiation over the territory of other countries in the absence of an agreement to the contrary.[103] The first group of regulations increases the complexity and, therefore, the cost of the necessary receivers, thus reinforcing the economic factors limiting the application of direct broadcast technology. The second group is arguably identical in effect to the prior consent regime supported by advocates of a restrictive approach to the technology.

An international consensus on principles to govern direct broadcasting should strike an effective balance between the interests motivating technological progress and those advocating a restrictive regulatory response. At present an imbalance exists in favor of regulation, with the consequences, first, that the implementation of the technology is likely to be deterred, and second, that agreement in the international area is unlikely until an equilibrium is established. While policy considerations may dictate some regulation at this time, any regulatory scheme should reflect a realistic assessment of the impediments to technology applications already established by technical and economic factors and existing regulation. Although the delegates to the fifteenth session of the Legal Sub-Committee were unable to reach a consensus on the key issues of prior consent, program content and spillover, the foundation for compromise seems to be present, and an effective accommodation of the competing interests upon that foundation should bring to fruition attempts to establish preliminary international regulatory structures to direct the development of direct broadcast technology.

Negotiations in the Working Group and the Legal Sub-Committee have failed thus far to reach agreement on the key questions of prior consent, program content, spillover and equal access,[104] and the resolution of these points of conflict would make possible the establishment of a consensus on a full range of general principles to guide the development of direct broadcast technology. The evolution of national

positions during the fifth session of the Working Group and the fourteenth and fifteenth meetings of the Legal Sub-Committee suggests that agreement will be reached in the next few years on a set of principles designed to protect the interests of those states concerned with direct broadcasting's potential for abuse without imposing undue restriction on, and consequently delaying, the development and operational implementation of the technology. The discussion below projects probable bases for compromise derived as a result of examination of the key points of conflict remaining after the May 1976 session of the Legal Sub-Committee.

1. *Limited Prior Consent*

The growing pressure for protection against real or imagined abuses of the technology suggests that the final declaration of principles probably will center around a provision which would permit direct broadcasting only when the receiving state has given its express consent. Nearly every proposal before the Working Group and the Legal Sub-Committee has recommended the establishment of a prior consent regime,[105] and the United States has been the only major dissenter.

Three main arguments have been raised against the adoption of a prior consent rule. First, prior consent is said to abrogate the principle of the free flow of information embodied in the Universal Declaration of Human Rights and other international instruments.[106] However, the principle, even if established as binding upon all nations, is not absolute. In

the International Covenant on Civil and Political Rights, for example, Article 19(2) delineates the free flow principle. In the third paragraph of that article, however, certain restrictions are permitted, including those for the preservation of the rights and reputation of others, and the protection of the national security, the public order, and public health and morals. Also imposing limits on the free flow principle, Article 20 provides:

> 1. Any propaganda for war shall be prohibited by law.
>
> 2. Any advocacy of national, racial or religious hatred that constitutes incitement to discrimination, hostility or violence shall be prohibited by law.[107]

Thus, the argument that the principle of free flow of information would be improperly abrogated by a principle granting a receiving state a right of prior consent may exaggerate the scope and legal significance of the principle. A better approach would be to provide for a flexible balance with other principles.[108]

The second major argument against the prior consent principle is that any restrictive regulation is, for the near future at least, premature. The problems likely to arise with the use of direct satellite broadcasting cannot be effectively evaluated at this time, first, because the necessary technology is not yet adequately developed, and second, because no country has concrete plans to deploy an operational system capable of broadcasting directly to

unaugmented receivers.[109] That argument could be allayed significantly by the decision to approve a declaration of principles rather than a binding treaty.

Another argument against prior consent is that although such a rule would dispel fears of intrusive transmissions, it could also frustrate the development of direct broadcasting technology.[110] Rejection of prior consent, however, seems equally likely to hinder rather than promote technological development.[111] The United States, for example, is interested primarily in broadcasting by commercial entities. If these entities intend to broadcast normal commercial programming based on advertising, most receiving states seem unlikely to take the steps necessary to make direct broadcasting commercially feasible, especially by encouraging production and installation of augmented receivers. If these elements are absent, direct broadcasting based on commercial programming would remain unprofitable for some time. If, on the other hand, broadcasters would provide only educational programming, direct broadcasting could become profitable, but only under contract with the receiving state. In that case, however, the receiving state would undoubtedly insist on some control with respect to frequencies used, broadcasting time, and at least to some extent, over the nature of the programming.

By accepting a prior consent rule, the United States could expect to derive important benefits, including the creation of an atmosphere conducive to early widespread

implementation of operational direct broadcasting. The establishment of such a rule would facilitate bilateral and multilateral exchanges leading eventually to the creation of regional organizations for satellite broadcasting.[112] In addition, the United States could expect to gain support from those countries which traditionally support the free flow of information, but which have advocated a prior consent rule to prevent the imposition of one country's values on others through direct broadcasting.[113] Finally, rapid implementation would maximize the benefits the United States expects to derive from the export of direct broadcasting hardware and technical assistance.

The acceptability of a prior consent regime to proponents of the free flow principle is also dependent upon the content of other components of the legal regime. The Soviet Union, for example, has consistently tied its prior consent proposal to principles limiting program content.[114] The Swedish-Canadian proposals have omitted any mention of program content, preferring to leave any limitations to specific agreements between the broadcasting and receiving states.[115] Since the negotiations necessary for a prior consent regime would probably give the receiving state some control over content, the Swedish-Canadian approach seems likely to prevail, because it gives adequate protection against offensive programming, while avoiding the difficult and excessively time-consuming process of negotiating a set of limits on program content which would be both effective and universally acceptable.

The Swedish-Canadian prior consent rule has, however, been criticized as giving inadequate protection to the free flow of information, because it fails to place adequate limits on the receiving state's right to deny its consent. As presently drafted, the joint proposal would apparently permit the receiving state to withhold its consent arbitrarily and without any obligation to consider the principle of free flow of information.[116] In addition, the Swedish-Canadian recommendations seem to permit the receiving state to withhold its consent on a program-by-program basis. Such an extensive right of review would permit prior restraint on free speech and would, by permitting official examination of each program, unnecessarily burden the flow of information across national borders.[117]

Two sets of limitations on a strict prior consent rule will probably result from the pressure to preserve an atmosphere conducive to technological progress. First, where the broadcast signal is not actually receivable in the receiving state with available equipment, consent is not likely to be required.[118] Second, the negative effects on the free flow of information of an unlimited consent requirement could be mitigated by tailoring the requirement closely to the optimum balance between the free flow of information and the purposes for conditioning the right to broadcast on the receiving state's consent. The 1972 UNESCO declaration on guiding principles for direct broadcasting distinguishes among four main categories of programming, and recommends basic principles for each type. Article V(1)

declares that the main objective of direct broadcasting with respect to the free flow of information is "to ensure the widest possible dissemination among the peoples of the world, of news of all countries, developed and developing alike.[119] The second paragraph of Article V imposes no requirement on news broadcasts other than to make every effort to ensure factual accuracy and to identify the source of the news broadcast and, where appropriate, of particular news items.[120] In the case of direct broadcast news programming, the receiving state's right to consent will be limited to the right to demand assurances of the factual accuracy and identification of news sources.

Article VI of the UNESCO declaration establishes the right of the receiving state to determine the content of educational programming broadcast via satellite to its people and, in cases where such programming is produced in conjunction with other countries, to take part in the planning and production on an equal footing.[121] The receiving state's interest in preventing propagandistic or otherwise offensive programming is strongest with respect to educational programming. In that area, receiving states will probably secure a relatively unrestrained right to deny their consent.

The interest of the receiving state is somewhat weaker in the case of cultural programs, including artistic performances and sporting events. In such cases, the UNESCO declaration called for a balance between the enrichment of all cultures through cultural exchange, while respecting the values of each

culture and the right of all peoples to preserve their cultures as part of the "common heritage of mankind."[122] Debates in the Legal Sub-Committee suggest the evolution of a consensus on a provision permitting the receiving state to deny its consent to cultural programming only where it can demonstrate that substantial harm to its own culture would result from transmission of the challenged program.[123]

The final programming category delineated by the UNESCO declaration related to commercial advertising. Implicitly recognizing the potentially disruptive influence of consumer-oriented advertising originating in more advanced societies, the UNESCO declaration called upon the broadcasting state to reach a specific agreement with the receiving state prior to the transmission of commercial advertising.[124] Since advertising is one of the programming areas most threatening to less developed states,[125] and since the free exchange of advertising is less essential to values underlying the free flow of information than other types of programming,[126] the establishment of a relatively unrestricted right of the receiving state to deny its consent appears probable. The inclusion of a principle giving the receiving state the right to deny its consent--subject to the conditions described above--to direct satellite broadcasts would provide an optimum balance between legitimate interests in both the free flow of information and national political and cultural integrity.

2. *Spillover*

Another criticism of the prior consent rule is that it would interfere with direct broadcasting by giving the right to deny consent not only to the intended receiving state, but also to any neighboring state inadvertently irradiated by the satellite.[127] Initially, spillover is not likely to be a major source of friction because the first direct broadcast systems will probably be national systems in large, underdeveloped countries, followed shortly by regional systems based on regional linguistic and cultural similarities.[128]

Once spillover becomes a source of conflict, however, the undesirable effects could be limited through the exercise of control by the government of the receiving state over community receivers. That solution, however, carries several undesirable consequences. First, the cost of avoiding the effects of spillover would be borne entirely by the receiving state.[129] The costs include not only the financial cost, but also the political costs of appearing to impose censorship for the benefit of the government. Second, government control of receivers would tend to subjugate freedom of information to direct and indirect assertions of national security interests.[130]

The Legal Sub-Committee is more likely to place the burden of reducing spillover on the broadcasting state, thereby providing some protection to the spillover states, while reducing the incentive for receiving states to exert international political pressure for broader restrictions. The growing consensus is based primarily

on Article 7, §428A of the Radio Regulations adopted by the ITU at its 1971 convention. Paragraph 428A requires the broadcasting state to reduce spillover to the maximum extent practicable unless a prior agreement has been reached between the broadcasting state and the states receiving spillover.[131] Building on that foundation, the Swedish-Canadian proposal to the fourth and fifth sessions of the Working Group provided that the right of consent shall apply in those cases:

> (a) where coverage of the territory of a foreign State entails radiation of the satellite signal beyond the limits considered technically unavoidable under the Radio Regulations of the International Telecommunication Union or
>
> (b) where notwithstanding the technical unavoidability of spill-over to the territory of a foreign State, the satellite broadcast is aimed specifically at an audience in that State within the area of spill-over . . . .[132]

The Legal Sub-Committee could yield to pressure by the United States to extend the Swedish-Canadian proposal so that the limited prior consent rule as described above would apply in all cases <u>except</u> where:

1) the elimination of spillover is considered technically impossible under the present state of the art, as determined in accord with the ITU Radio Regulations;
2) the direct broadcast system is entirely domestic in character; or
3) the broadcast, although irradiating a part of the complaining state's territory, is not actually receivable using standard or easily augmented receivers readily available in the area irradiated.

second paragraph would restore the right to deny consent where the spillover broadcast was aimed specifically at an audience within the receiving state. A third paragraph taken from the Soviet draft declaration submitted to the fifth session of the Working Group could be added to the spillover article to ensure that international cooperation and consultation will govern the relations between broadcasting and receiving states with regard to spillover:

> 1. If any State has reason to believe that activities connected with direct television broadcasting planned by that State will cause potentially harmful interference to other States or will lead to unintentional radiation of their territory, it shall hold appropriate consultations before undertaking such activities.
>
> 2. If a State has reason to believe that unintentional radiation of its territory will occur as a result of direct television broadcasts by another State, it may request that appropriate consultations be held. If, as a result of such unintentional radiation, foreign programmes can be received in the territory of a State by ordinary receivers or by receivers fitted with simple additional devices, the broadcasting State shall immediately enter into consultations with the former State on its request regarding the content of the programmes received.[133]

Participation or Equal Access

A further controversial issue is the question whether receiving states should participate in the use of direct broadcast systems. The 1972 UNESCO declaration of principles for direct broadcasting set forth the right of the receiving state to participate on an equal footing with any other state in the production of educational programming destined for the receiving

state.[134] The Swedish-Canadian draft declaration submitted to the fifth session of the Working Group went further, giving the receiving state not only the right to deny its consent to satellite broadcasting, but also to participate in activities related to programming broadcast into its territory.[135] It has further been proposed that all states receiving broadcasts should have the right--in law and in fact--to have access to the system on an equal footing, including the rights of access to transmitters and to sufficient international assistance to enable those states to make meaningful use of the access rights.[136]

Both the UNESCO and Swedish-Canadian participation principles are intended to enhance the receiving state's ability to influence the programming broadcast to its citizens. In Article VI(2), he UNESCO version gives the receiving state the right to participate on an equal footing in the planning and production of programming, but only as an adjunct to the provision proclaiming the right of the receiving state to determine the content of educational programming.[137] By including its participation provision in the general prior consent paragraph, the Swedish-Canadian draft declaration extends the right to participate to encompass all types of programming and all stages of programming activities.[138] The inclusion of a right of participation for the purpose of ensuring the receiving state's power to affect the content of broadcasts beamed to it would alter the balance in favor of those interests demanding that the receiving states' cultural and political integrity be protected against the intrusion of unwanted foreign

broadcasting over the interests in realizing the benefits of direct broadcasting through operational use. As a result, operational application would probably be delayed substantially.

A second rationale advanced for inclusion in the proposed declaration of a principle permitting the receiving state to participate in direct broadcasting over its territory is to give effect to the principle of free flow of information.[139] On numerous occasions, potential broadcasting states, particularly the United States, have based their arguments supporting an unrestrictive regulatory scheme for direct broadcasting at least partially on the contention that a restrictive regime would inhibit the free flow of information.[140]

Sound policy considerations support the integration of the free flow principle into the structure of legal principles to govern direct broadcasting. At present, the two most—important requirements for effective development of satellite communication technology for operational use are, first, the uninhibited exchange and testing of information and ideas, and second, the assurance that the value of investments in development will not be nullified by the imposition of unnecessarily restrictive regulations upon innovative systems. A legal structure designed to promote rather than inhibit the free flow of information will encourage designers and planners to explore the potential uses and benefits of recent technical advances.

Viewed pragmatically, however, the principle of free flow of information is reduced to a fiction unless it is coupled with a second principle calling upon the international community to promote development of satellites and ground facilities in such a way as to facilitate access to transmitter and program production facilities by any state willing to contribute to development and operating costs. In the absence of an equal access clause, free flow of information would probably mean a unidirectional flow from the more developed countries to the less developed. The principle of free flow opposes not only unnecessary limitations on the influx of information from abroad, but also monopolization of a medium for ideological purposes.[141] That potential imbalance is the source of the fears of cultural and economic imperialism expressed by potential receiving states, with detrimental effects for both international cooperation and technology development. The inclusion of an equal access provision, however, would both allay those fears and set in motion a search for means to achieve the goal of equal access without sacrificing the interests of the broadcasting states.

Although an equal access principle is likely to be included in a declaration of principles, the lack of certainty regarding the circumstances under which operational direct broadcasting will be conducted makes necessary a particularly careful choice of language to avoid interference with the balance of interests

established in the preceding discussions of the prior consent and spillover provisions. The form of the final participation provision probably will parallel the principle presented by the United States in its draft declaration submitted to the fifth session of the Working Group. This draft entitles every state to share in the benefits of direct broadcasting and provides further that such sharing "should increasingly include, as practical difficulties are overcome, opportunities for access to the use of [direct broadcasting] technology for the purpose of sending as well as receiving broadcasts."[142] As this right of access becomes available from a practical standpoint, allocation of transponder time should be made available on a non-discriminatory basis.

Presumably, a receiving state would exercise its right to obtain transponder time on a non-discriminatory basis at least initially for the purpose of transmitting its own programming to its own citizens. Self-sufficiency in that sense is desirable, and broadcasting states should be encouraged to provide the technical assistance necessary to achieve that goal. To impose an obligation to provide such assistance is, however, unnecessary since investment in technical assistance would provide a two-fold return. First, increased interest in direct broadcasting systems would accelerate demand for the exportation of the necessary technical equipment and software expertise from the broadcasting states.[143] Second, an increasing right of partici-

pation would create a greater community of interests between broadcasting and receiving states, with the result that the latter would promote rather than inhibit the operational application of direct broadcast technology.

II. IMPLICATIONS OF THE CPUOS DEBATES ON EARTH RESOURCES SATELLITES FOR SPACE INDUSTRIALIZATION

The second set of current activities which is likely to influence the future development of international space law centers around the CPUOS debates relating to international principles to govern the use of earth resources satellites. Consideration of the earth resources satellite issue began with the establishment of the Working Group on Remote Sensing of the Earth by Satellites.[1] The CPUOS Legal Sub-Committee devoted a small portion of its 1977 session to a preliminary review of relevant issues.[2] Since then satellite remote sensing has had significant attention in each subcommittee session.

A. Main positions

During the evolution of the satellite remote sensing debates, three major blocs have emerged. The main tenets of each position are represented in a series of three proposals for international guidelines for the use of earth resources satellite technology.

1. Argentina and Brazil: Treaty on Remote Sensing of Natural Resources by Means of Space Technology, Draft Basic Principles

At the 1974 session of the General Assembly, the delegations of Argentina and Brazil jointly submitted a draft treaty to govern satellite remote sensing.[3] The draft is now co-sponsored and strongly supported in all of its provisions

by each of the other Latin American delegations represented on CPUOS: Mexico, Venezuela and Chile. Although a number of delegations privately express support for the Latin American submission, only the Latin American delegations have argued directly for adoption of the draft treaty.

The tone of the draft is established in its preamble, where it refers both to consequences of the implementation of remote sensing technology "which create legal problems that require an *immediate and equitable solution in the framework of a general treaty* . . ." and to the concept of permanent sovereignty over natural resources, which allegedly gives a state the sovereign right to control not only the natural resources located within its territory, but information regarding those resources as well. The need for a binding international legal framework is a recurrent theme in formal speeches and private conversations not only among the Latin American delegations, but among the Third World and Soviet bloc delegations as well.

The Latin American draft treaty proposes in Article V to implement the alleged rights of permanent sovereignty over natural resources by imposing a duty on any state engaged in earth resources satellite activities to refrain from gathering data from the territory of any state which had not consented. In addition, Article IX would prohibit any state obtaining information regarding the natural resources of another state through satellite remote sensing from conveying such information in any manner "to a third state, international organization *or private entity*, without

the express consent of the [state] to which the natural resources belong . . ." If entered into force, these prohibitions would be strengthened by Article XIII which contains a provision similar to that in Article VI of the 1967 Outer Space Treaty[4] imposing on each state the responsibility to ensure the compliance of its nationals, including commercial entities, with established rules of international law. Article VI of the Latin American proposal would permit a party to the draft treaty to take all measures authorized by international law to protect its territory against any unauthorized surveillance. Both prohibitions could interfere with the provision of commercial earth resources services.

If one party to the proposed treaty authorized another to gather information regarding the former's natural resources, the draft treaty would provide the former with specified benefits. In exchange for its consent, Article VII would entitle the surveilled state to participate in the satellite remote sensing activities of the state granted consent on the basis of arrangements made during negotiation of consent, except that as a minimum such arrangements must include a guarantee that the sensing state will provide technical assistance to the consenting surveilled state. In addition, once the latter has given its consent, Article VIII of the draft would give it the right to full and unrestricted access to "all data obtained through those activities." That provision does not specify whether or not "all data" is limited to data related to the surveilled state's territory.

However, such an interpretation seems correct, in light of draft Article IX, which would prohibit the sensing state from distributing any earth resources data it had gathered relating to the territory of another state without the express consent of the surveilled state.

In summary, the Argentine-Brazilian Draft Treaty would:

1. impose legally binding obligations under international law;
2. subject satellite remote sensing activities to the prior consent of the sensed state;
3. subject data dissemination activities to the prior consent of the sensed state; and
4. require participation and broad-scale technical assistance as consideration for the consent of the sensed state.

2. France and the Soviet Union: Draft Principles Governing Activities of States in the Field of Remote Sensing of Earth Resources by Means of Space Technology

The second proposal currently before the Committee on the Peaceful Uses of Outer Space was presented jointly by the Soviet and French delegations in May 1974.[5] At present, the Soviet-French draft declaration enjoys monolithic support from the Eastern European members of the committee· Bulgaria, Czechoslovakia, the German Democratic Republic, Hungary, Poland, and Romania. In addition, the proposal shares with the Latin American draft treaty the support of a number of non-aligned and Third World countries including Egypt, Iran, Chad, Mongolia and Nigeria.

The theoretical underpinning of the Soviet-French draft resembles that of the Latin American approach, but differing interests have created some important divergences.

After restating the principles in Article I and III of the Outer Space Treaty relating to free use of outer space and compliance with international law and the United Nations Charter, the Soviet-French draft calls upon sensing states to respect in particular the principles of sovereignty, placing special emphasis on the right of a state to exercise permanent sovereignty over natural resources as a basic element of self-determination.[6] However, rather than applying strict prior consent provisions like that contained in the draft treaty to the gathering of earth resources data by satellite, the Soviet-French proposal would implement the concept of permanent sovereignty over natural resources primarily by granting the surveilled state the right to deny its consent to dissemination of information related to its resources to any private party, international organization, or other government, or using the data in any other manner detrimental to the interests of the surveilled state.[7] An exception would permit the sensing state to make public without the consent of the surveilled state information relating to natural disasters or phenomena detrimental to the general environment.[8]

In other respects, the draft declaration is similar to the Latin American proposal. Article 4 would require the sensing state to relay data regarding the territory of another state to the latter on mutually agreeable terms. In addition, the

surveilled state would be granted the right to participate in the remote sensing activities of the sensing state on the basis of a consensus between the two states.[9] Finally, the Soviet-French proposal would permit any state to receive and process on the basis of equality and on mutually acceptable terms earth resources satellite information relating to territory outside the jurisdiction of any state.[10]

The primary reason for the Soviet Union's opposition to a prior consent regime with respect to data acquisition is that it intends to expand its activities in the field of remote sensing and does not wish to be limited by restrictive principles or treaty provisions. At the 1977 session of the CPUOS Scientific and Technical Sub-Committee, the Soviet delegation made numerous references to Soviet activities in the area of satellite remote sensing. The Soviet Union has attempted privately to persuade the United States to accept prior consent with regard to data dissemination in order to ensure ultimate adoption of an international regime which would not limit data acquisition activities.

The Soviet position on the question of commercial implementation of the technology should be carefully monitored, since the Soviets currently consider the sale of earth resources data and services to be inappropriate. Although it is possible that Soviet opposition is based solely on its argument that no legal basis currently exists for the sale of those items, a more

credible explanation is ideological resistance to "capitalist enterprise." In the CPUOS debates on direct broadcast satellites, the Soviets have proposed that activities by non-governmental entities be prohibited.

If adopted, the Soviet-French draft declaration would:

1. not in itself impose legally binding obligations on members of the international community;

2. permit data acquisition via satellite in the absence of the prior consent of the sensed state,

3. subject data dissemination to the prior consent of the sensed state; and

4. place participation of the sensed state in the earth resources satellite program of the sensing state on a contractual basis between the two states.

3. United States: Remote Sensing of the Natural Environment of the Earth from Outer Space, Working Paper on the Development of Additional Guidelines

In the context of these drafts the United States issued a working paper based on the considerations that the optimum benefits from earth resources satellite technology will depend on international cooperation and the sharing and use of data on a regional and global basis.[11] The keystone of the working paper is the provision in Article I that remote sensing shall be conducted in

> accordance with the principles of the United Nations Charter, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, and other generally accepted principles of international law relating to man's activities in outer space.

The reference to the 1967 Outer Space Treaty is particularly important in that respect, because it provides the legal foundation for the United States delegation's resistance to prior consent in any form. Article I(2) of the Outer Space Treaty provides:

> Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.

The American delegation has argued repeatedly, first, that this "free use" principle authorizes all satellite remote sensing activities in the areas above the vertical limits of territorial sovereignty, subject only to the requirement that contemplated uses be peaceful in nature, and second, that a prior consent requirement would be in direct conflict with the "free use" principle.

Building on that foundation, Article IV calls upon states with satellite remote sensing programs to encourage the broadest feasible participation in appropriate phases of those programs. In addition, Article V would require states receiving earth resources data directly from satellites to make that data available "to interested states, international organizations, individuals, scientific communities and others on an equitable, timely and non-discriminatory basis." The same article encourages sensing states to facilitate sharing of earth resources data by publishing lists of publicly available data.

To dispel concerns about mineral or grain futures speculation based on early reception of data, Article VI would require a sensing state to distribute any data it acquires regarding the territory of another state to its government as soon as practicable, and at least as soon as to any state other than the sensing state. In addition, sensing states would be required under the American draft to facilitate direct reception of data from earth resources satellites by other interested states on equitable terms, if technically possible. Further, Article VIII calls upon sensing states "within their capabilities to endeavor to assist on an equitable basis" non-sensing states in understanding the techniques and benefits of satellite remote sensing. Articles IX and X encourage regional cooperation as well as assistance by international organizations for the purpose of facilitating operational applications of earth resources satellite technology.

The United States working paper differs in several significant respects from the two proposals described above. First, the Argentine-Brazilian submission is a draft treaty which, if entered into force would be legally binding upon the signatories. Although the Soviet-French proposal was presented in the form of a draft declaration, which would be non-binding if adopted, a large number of the delegations supporting that proposal have made reference both publicly and privately to the need for a binding international instrument, indicating reasonably strong support in that bloc for a treaty on remote sensing. In contrast, the United States working paper takes

a much less concrete approach, at least from a legal perspective, offering instead "possible operative provisions." The starkness of the contrast is enhanced by the fact that the main issue of the debate over the form the final instrument should take is not whether it should be a treaty or a declaration of principles, but rather whether a declaration should precede the treaty or whether CPUOS should draft a treaty as the initial step. Most delegations are persuaded that the final instrument will be -- and ought to be -- a treaty. The only remaining question relates to the presence or absence of intermediate steps.

Second, the United States working paper rejects by omission the concept of permanent sovereignty, at least insofar as it is said to extend to the right to restrict access even to information regarding a state's natural resources. As a result, the working paper does not subject either acquisition or dissemination of earth resources data to the consent of the surveilled states. On the contrary, the American draft promotes a policy of open dissemination of data. That difference is important in light of the strength of the support for prior consent evidenced in speeches and private remarks by representatives of the members of the Committee on the Peaceful Uses of Outer Space.

Third, the working paper makes repeated reference to broad international participation in the remote sensing activities of space powers, technical assistance and regional cooperation. Although the other drafts make some reference to those principles, the American proposal takes a relatively strong position. The reasoning is that the defeat of an earth resources regime

based on prior consent will only occur if the United States can demonstrate a strong likelihood that substantial benefits will inure to other countries if the American proposal is adopted.

Fourth, the proposal submitted by the United States would not, like the Latin American draft, impose international responsibility on each state for the activities of its nationals. The advantage of including such a provision in the instrument ultimately adopted is that it implicitly recognizes and authorizes non-governmental entities, especially corporations, to conduct operations in outer space. The potential disadvantage that the government would be responsible for enforcing international legal prohibitions against its own nationals is not a new disadvantage, since a similar clause appears in Article VI of the 1967 Outer Space Treaty. If such a provision were adopted by CPUOS in the context of earth resources technology, the private sector would be able to argue that an international consensus approving commercial satellite remote sensing activities has been established, and that domestic policy should be made consistent with that consensus.

In summary, the United States position is based on the following main principles:

1. no prior consent for either satellite data acquisition or data dissemination;
2. open dissemination of data to any customer;
3. dissemination to sensed state as soon as to any other government, and
4. broad technical assistance and international participation.

B. Current Status of the Earth Resources Satellite Debate

During its fifteenth session, CPUOS Legal Sub-Committee established a working group on the legal implications of remote sensing of the earth from outer space. On the basis of five "common elements" derived from the draft declaration submitted by the Argentine, Brazilian, Soviet, French, and American delegations, as well as from views expressed during the sub-committee's fourteenth session,[12] the working group formulated five draft principles applicable to satellite remote sensing during the 1976 session. In addition, the working group identified three new common elements.[13]

1. *Principle I*

As formulated by the Legal Sub-Committee, the first draft principle provides:

> Remote sensing of [the natural resources of the earth] [and its environment] from outer space and international co-operation in that field [shall] [should] be carried out for the benefit and in the interests of all countries [mankind], irrespective of their degree of economic or scientific development, and taking into consideration, in international co-operation; the particular needs of the developing countries.

Principle I is based on Article I(1) of the 1967 Outer Space Treaty which requires that the use of outer space be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development. The impact of the draft principle on operational implementation of remote sensing technology is dependent on

the construction of the parallel language in Article I.[14] Some CPUOS delegations have argued that the treaty language entitles less developed countries to enjoy the benefits of earth resources satellite technology even though they are unable to conduct independent space programs. If that position became generally accepted, the range of institutional arrangements available to the United States for implementing a national earth resources satellite system on an operational basis would be limited. In particular, the option to provide earth resources information services on a commercial basis would be jeopardized. Because of the potentially adverse consequences for both national and international interests which could result from adoption of the restrictive interpretation of Article I of the Outer Space Treaty and Principle I of the draft declaration on satellite remote sensing, it appears that all states, including less developed countries, will benefit most from the combination of organizational and legal principles which promote initiation of earth resources information services on an operational basis as quickly as possible to the broadest range of potential users. If scope and quality of service provides the basis for international policy in this area, the restrictive approach would be dysfunctional. However, if national participation is considered by the international community to be more important than service characteristics, the interpretation of Principle I urged by the developing countries is likely to be adopted. The latter approach is,

however, not likely to be with the near-term interests of the entities which decide to invest in the industrialization of outer space.

The text of the draft principle contains three sets of bracketed words. The first pair was apparently inserted as a result of the suggestion by the United States delegation that the scope of the draft declaration be expanded from natural resources to include the entire natural environment.[15] In light of the possibility that the final declaration may be somewhat restrictive in character, an expansion of the scope of coverage has given rise to some concern in the private sector. The second pair of brackets resulted from disagreement among the CPUOS delegations regarding the strength of the declaration to be adopted. However, since the final product is likely to be a non-binding declaration of principles, the disagreement in this point is not considered significant.

The proposed use of the word "mankind" rather than the word "countries" in the third set of brackets may well result in increasing reference to the broader concept of the "common heritage of mankind." This broader concept has been embodied in General Assembly resolutions and negotiations relating to the law of the deep seabed,[16] as well as to the moon treaty presently under consideration by CPUOS,[17] and has been used by less developed countries to assure access on an equitable basis to the natural resources of both areas regardless of their ability to exploit them.[18] A parallel construction might

enable a state to obtain satellite-acquired remote sensing information, regardless of its ability to pay for the information. Although mentioned here in the context of the remote sensing satellite debate, the notion that all states should have access to the products of space activities without consideration of financial ability to participate in these activities has potentially adverse implications for all facets of space industrialization. In particular, adoption of the "common heritage of mankind" approach could inhibit commercial participation in the development of outer space.

2. *Principle II*

The second draft principle formulated by the working group provides:

> Remote sensing of [the natural resources of the earth] [and its environment] from outer space [shall] [should] be conducted in accordance with international law, including the Charter of the United Nations and the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies.

The language is consistent with and apparently based on the text of Article III of the Outer Space Treaty. In addition, the text is essentially identical to the text of the second common element formulated during the Legal Sub-Committee's fourteenth session.[19] The two sets of brackets were included as a result of the same general positions which necessitated inclusion of parallel bracketed terms in Principle I.

In its present form, Principle II would not have any adverse impact on optimum availability of benefits, unless either general international law or the terms of a remote sensing declaration were deemed to include such concepts as "prior consent," "the common heritage of mankind" and "permanent sovereignty over natural resources." To date the United States has been consistent in its opposition to adoption of prior consent principles with respect to both acquisition and dissemination of satellite-acquired data. The same approach should be taken with respect to the concept of "permanent sovereignty over natural resources," which has supplied one of the main policy foundations for prior consent arguments. As embodied in a series of General Assembly resolutions, the concept would give each state the right to control access not only to its natural resources but to information regarding those resources as well.[20] Although an examination of those texts demonstrates that the concept has not yet been extended that far, the extension would be accomplished by adopting a principle similar to that in a working paper submitted by Mongolia during the subcommittee's fifteenth session which provides.

> States participating in remote sensing should respect the principle of full and permanent sovereignty of all States and peoples over their wealth and natural resources as well as their inalienable right to dispose of their natural resources and of information concerning those resources.[21]

Because of the potential inhibiting effect it could exert on the establishment of an operational earth resources satellite

system, the concept of permanent sovereignty should be limited to its current scope. Opposition to the Mongolian proposal is also considered important, because such opposition would undermine support for the extreme prior consent proposals. As a result, compromise would be facilitated in other areas.

3. *Principle III*

As drafted by the Working Group on Remote Sensing at the fifteenth session of the Legal Sub-Committee, Principle III provides:

> 1. States carrying out programmes for remote sensing of [the natural resources of the earth] [and its environment] from outer space [should] [shall] promote international co-operation in these programmes. To this end, sensing States [should] [shall] make available to other States opportunities for participation in these programmes. Such participation should be based in each case on equitable and mutually acceptable terms due regard being paid to elements . . .
>
> 2. In order to maximize the availability of benefits from such remote sensing data, States are encouraged to consider agreements for the establishment of shared regional facilities.[22]

Principle III is based on two common elements identified by the Working Group on Remote Sensing during the fourteenth session of the Legal Sub-Committee.[23] According to the session report, the delegations agreed:

> 1. that the maximum benefits to all countries could be obtained by international co-operation at all levels, particularly on a regional basis; and
>
> 2. that States undertaking programmes for remote sensing activities by means of space technology should encourage international participation.[24]

The texts of the draft principle and the underlying common elements raise the question of the meaning of the terms "cooperation" and "participation" and the relationship between the two. Article I(3) of the Outer Space Treaty requires states to "facilitate and encourage international co-operation in (scientific) investigations." Since the term "co-operation" is not used again in any operative provision which relates to activities in outer space,[25] it may be construed in the limited context of Article I(3) relating to scientific investigation. Thus, "co-operation" is not necessarily mandated, except for experimental activities. The Outer Space Treaty does not give any significant clue to the meaning of "co-operation." The fact that Paragraph 1 of Principle III refers to the promotions of "international co-operation <u>in</u> (the) programmes" of sensing states suggests that the working group equated "co-operation" with "participation." That inference is supported by the second sentence of Paragraph I which establishes "participation" as the most important element, if not the only element, of "co-operation."

Actual foreign participation in programs conducted by the United States or its nationals would jeopardize corporate interests. First, to the extent that the federal government permits foreign participation, the alternatives for interface between the public and private sectors are limited. If, for example, the federal government cooperates in the construction of an extensive network of readout stations for distribution

of raw data, it cannot logically support commercial implementation. Second, foreign participation in profit-oriented operations would both undermine the commercial basis and jeopardize United States technological leadership. Similarly, significant participation in United States programs is likely to result in international pressure to limit providers of data and services to activities in their own regions, thus reducing both competition and the quality and scope of services available to users.

The United States delegation is not likely to support deletion of the references to participation, because it has supported strong cooperation and participation as a means of avoiding imposition of prior consent principles. In fact, the draft declaration submitted by the United States delegation during the thirteenth session of the Legal Sub-Committee contains the provision that:

> States undertaking programmes designed for remote sensing of the natural environment from satellites shall encourage the broadest feasible international participation in appropriate phases of these programmes.[26]

Three alternatives for minimizing these difficulties could be considered. First, Paragraph 1 of the third principle could be amended to limit its scope to experimental activities. Second, the language relating to participation could be made discretionary rather than mandatory, and could be limited as provided in Article 4 of the working paper submitted by the United States delegation during the thirteenth session of the

Legal Sub-Committee to "feasible participation" in "appropriate phases" of United States programs. Third, the paragraph could be amended to limit the participation foreseen therein to governmental, as distinguished from commercial, programs.

The language in the final sentence of Paragraph 1 relating to the terms of participation raises another problem of construction. That sentence, which places participation on the basis of "equitable and mutually acceptable terms," appears to be a broadened version of Article 5(a) of the draft declaration submitted jointly by the Soviet and French delegations which would have entitled any state whose territory is affected by the remote sensing activities of a second state to participate in the latter's program on "equal and mutually acceptable terms." Although the phrase "mutually acceptable terms" appears to be a broadened version of Article 5(a) of the draft declaration submitted jointly by the Soviet and French delegations which would have entitled any state whose territory is affected by the remote sensing activities of a second state to participate in the latter's program on "equal and mutually acceptable terms." Although the phrase "mutually acceptable terms" appears to provide a basis for commercial implementation, questions of interpretation could arise, since the source of the provision suggests an intention to place implementation on a non-commercial basis. Further, the omission from the draft principle of the language in the Soviet-French draft which implicitly limits participation to those states affected by the remote sensing

program in question would expand the scope of foreign participation and hence exacerbate the adverse consequences of such participation. The most desirable solution to the problem appears to be to ensure that any participation provision is discretionary in nature and limited to those states which are significantly affected by the program in which the sensed state wishes to participate.

The impact of the second paragraph of Principle III on operational implementation depends on the organizational or institutional configurations selected for routine operations. If, as suggested by CPUOS, complete reception and data management facilities are to be established in each region, the international market for private sector services could be significantly diminished. Consequently, the regional facilities recommended in Paragraph 2 of Principle III should be limited to facilities for specialized processing of preprocessed data and distribution of information products.

4. *Principle IV*

The fourth draft principle formulated by the Working Group on Remote Sensing provides:

> Remote sensing [of the natural resources of earth] [and its environment] from outer space [should] [shall] promote the protection of the natural environment of the earth. To this end States participating in remote sensing [should] [shall] identify and make available information useful for the prevention of phenomena detrimental to the natural environment of the earth.[27]

In its present form, the language of the fourth principle would not adversely affect implementation of the technology, even if made mandatory. The use of information products as implied in the second sentence for the prevention of phenomena detrimental to the environment could expand the market for earth resources information products. However, to ensure implementation of this principle in a manner consistent with practical operational considerations, recipients of the information should be identified as international organizations responsible for environmental management and to governments of states likely to be affected adversely by phenomena detrimental to the environment. That limitation could be incorporated through the addition of language at the end of the text which would make available to all states likely to be affected and to concerned international organizations. In addition, the information should be made available on "mutually agreeable" terms.

5. *Principle V*

The fifth draft principle provides:

> States participating in remote sensing of [the natural resources of the earth] [and its environment] from outer space [should] [shall] make available technical assistance to other interested States on mutually agreed terms.[28]

If implemented in its present form, Principle V would create pressure to export every facet of earth resources satellite technology and related ground technologies. That pressure could undermine both United States technological leadership and the

basis for the provision of commercial earth resource information services not to mention possible national security concerns. However, if the provision were limited to technical assistance relating to specialized processing of data products and to the creation of infrastructures in less developed countries capable of applying information products effectively, it would be more likely to result in rapid national and regional development than would concentration of efforts on the sale of expertise, reception and preprocessing equipment. Since that approach would expand rather than contract the international market for the services not only for providers of satellite data services but for American exporters generally, the focus on infrastructure development appears desirable. Similarly, since "information" rather than "data," as those terms are defined by the Working Group on Remote Sensing[29] is the source of the benefits to be derived from satellite remote sensing, the emphasis of international cooperation and technical assistance programs should be placed on the acquisition and application of "information."

6. *Principle VI*

During its 1977 session, the Legal Sub-Committee formulated a series of new draft principles, based either on previously identified common elements or on a consensus established during the 1977 session.[30] The first of these is Principle VI which provides:

> 1. The United Nations and its relevant specialized agencies [and the International Atomic Energy Agency] [should] [shall] promote international cooperation, including technical assistance, and play a role of coordination in the area of remote sensing of [the natural resources of the earth] [and its environment].
>
> 2. States conducting activities in the field of remote sensing of [the natural resources of the earth] [and its environment] [shall] [should] notify the Secretary-General thereof, in compliance with article XI of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.

This principle was based on the first of the common elements identified during the 1976 session.[31] In its present form, Principle VI makes a general statement regarding a possible coordinating role for the United Nations which would be desirable from the perspective of the United States if implemented within the limits described in the discussion of Principle V. The second paragraph merely applies Article XI of the Outer Space Treaty to satellite remote sensing and is considered inoffensive, provided the level of information required does not exceed the nature and scope of information currently supplied regarding satellite launches.

7. *Principle VII*

Principle VII, which provides:

> Information obtained by remote sensing [of the natural resources of the earth] [and its environment] indicating an impending natural disaster shall be disseminated as promptly as possible to those States likely to be affected.

was based on the second common principle identified during the 1976 session of the Legal Sub-Committee.[32] Adoption of this element in its present form also appears desirable. If included in a package of general services, the disaster warning

service could be used to demonstrate to other delegations that the value of potential benefits significantly exceeds the cost of potential abuses of earth resources satellite technology.

8. Principle VIII

Principle VIII provides:

> Taking into account the principles I and II above, remote sensing data or information derived therefrom [shall] [should] [not] be used by States [to the detriment of] [in a manner compatible with] the legitimate rights and interests of other States.

Based on the third common element,[33] that language is closely related not only to the concept embodied in Article IX of the Outer Space Treaty that states should conduct their space activities with due regard to the corresponding interests of other states,[34] but to the interpretation of Article I(1) urged by developing states which would prohibit activities in outer space, unless they are conducted "in the interests and for the benefit of all states."[35] Because of those similarities, Principle VIII is likely to generate similar controversies, particularly regarding the construction of the term "international detriment."

The bracketed phrases permit both a negative and a positive interpretation. However, from the perspective of potential private sector interests, both approaches could be considered detrimental, when read in the context of Article VI of the Outer Space Treaty which imposes international responsibility on states parties to the treaty for the space activities of their respective nationals, whether governmental or non-governmental

entities.[36] Broad or uncertain construction of the terms of Principle VIII could lead to restriction of legitimate, desirable activities, particularly based on commercial initiatives. Although private sector operations may be possible within the framework of such a principle, adverse political repercussions resulting from disputed constructions of the common element are considered both probable and detrimental to United States interests. Consequently, in its present form, the eighth draft principle is considered undesirable.

9. *Principle IX*

The ninth principle incorporated in the new draft was agreed upon during the 1977 Legal Sub-Committee without prior consideration during the 1976 session. Principle IX provides:

> States participating in remote sensing [of the natural resources of the earth] [and its environment], either directly or through relevant international organization [shall] [should] be prepared to make available to the United Nations and other interested States, particularly the developing countries, upon their request, any relevant technical information involving possible operational systems which they are free to disclose.

The apparent rationale for inclusion of this provision is to promote exchange of information regarding the characteristics of operational systems as a means of enabling developing countries to keep pace with technical and institutional developments. Since the availability of this type of information is likely to alloy some of the concerns of less developing countries concerning potential abuses of the technology, this level of information exchange is considered desirable.

10. *Principle X*

The second new principle formulated during the 1977 session provides:

> States [shall] [should] bear international responsibility for [national] activities of remote sensing [of the natural resources of the earth] [and its environment] [irrespective of whether] [where] such activities are carried out by governmental [or non-governmental] entities, and [shall] [should] [guarantee that such activities will] comply with the provisions of these Principles.

In essence, Principle X restates the provisions of Article VI of the Outer Space Treaty, and hence, does not necessarily increase the potential burdens imposed by the supervision requirement of that article. However, the fact of the restatement combined with the potential for more direct language indicates the existence of a trend toward full-scale national governmental supervision of all space activities. Consequently, Principle X has given rise to some concern in the private sector regarding the possible limitations on non-governmental space activities.

11. *Principle XI*

The final draft principle formulated this year by the Legal Sub-Committee provides:

> A sensed State [shall] [should] have timely and non-discriminatory access to data obtained by remote sensing [of the natural resources of the earth] [and its environment] from outer space, pertaining to its territory on reasonable terms [to be mutually agreed upon with the sensing State] and to the extent feasible and practicable, [shall] [should] be provided with such data on such terms [on a continuous and priority basis] [and in any case no later than any third state].

In some respects, this draft principle appears to correspond to certain of the positions taken by the United States in an attempt to avoid adoption of a prior consent regime. Particularly important are the classes relating to "timely and non-discriminatory access" and access "in any case no later than any third state." If ultimately adopted, the language of Principle XI could serve to limit the flexibility of operations available to the entity managing the system. In its present form, Principle XI could interfere with traditional private sector management and marketing procedures and should therefore be carefully examined prior to final adoption.

C. Prospects for Resolution of the Earth Resources Satellite Debate

The main tenet of the present United States policy is strict opposition to the adoption of an international regime based on prior consent. This approach is essentially consistent with the interests of the public and private sectors. If data acquisition were subject to the consent of the surveilled state, as proposed in the Latin American draft treaty, acquisition procedures would be disrupted, causing increased costs while decreasing the value of the data. Strict adherence to the prior consent rule on data collection would require the capability either to turn off the satellite sensors, or to separate out and dispose of information pertaining to the territory of a state which had not given its consent. The first approach would increase the cost of satellite construction and operation, and the second would increase processing time and costs. Both

approaches would be complicated by fluctuating geographic patterns of consent, especially in politically unstable regions. These consequences would affect the viability of both international and domestic earth resources services, regardless of the institutional configurations employed. In particular, with respect to operation of the space segment, the principle of prior consent would force operational entities to negotiate directly with foreign governments, which would in turn give rise to all of the problems which characterize relations between a sovereign and non-sovereign entity.

Related complications would arise if data dissemination were subject to prior consent. Both the Soviet-French and Latin American drafts would prevent transfer of satellite-acquired earth resources data from the government operating the satellite to any third party, public or private, without the express authorization of the surveilled state. If strictly construed, those provisions could prevent the United States government from distributing data to its own nationals, unless permitted by the foreign government in question. Strict construction seems warranted, since the provision would be meaningless if the United States government were free to disseminate all of the earth resources information in its possession to its nationals, who would in turn be free to convey the same information to any other entity, public or private.

In the absence of foreign governmental consent, American public and private entities could be inhibited from providing effective services in border areas, both because of the problems

of spillover and because of the inability to provide services regarding phenomena affected by stimuli which originate or operate exclusively in foreign territories. Although the domestic market would enjoy the advantages of the relatively cordial relations between the United States and the adjacent countries, the delays and potential instability associated with consent relationships would make the situation undesirable.

The same problems would be exacerbated in the international market. In most regions the relatively small areas controlled by each government would increase the problems arising from the need to incorporate information from the territories of another state into an effective analysis of conditions in the consenting state. In the same regions border tensions and other forms of competition between neighboring states will interfere with the process of securing the necessary authorizations. Even where consent is initially obtained, continuation is dependent on political factors.

As noted above, one of the main policy foundations for the prior consent proposals has been the argument that the concept of "permanent sovereignty over natural resources" embodied in a series of General Assembly resolutions gives a state the right to control access not only to its natural resources but to information regarding these resources as well. An examination of those texts demonstrates that the concept has not yet been extended that far. To date, the United States delegation has not demonstrated particularly strong opposition, probably because of the political dynamics within the Outer Space

Committee. Limitation of the concept of permanent sovereignty to its current scope could weaken support for the extreme prior consent proposals and make possible compromise on some basis which permits relatively free access to data.

As an alternative to the prior consent proposals, the United States delegation has offered a strong policy of open dissemination of data. One of the main arguments against prior consent is that a prior consent regime would either defeat implementation of the technology altogether or give a monopoly on remote sensing data to those highly industrialized states capable of operating their own satellites. Under the open dissemination policy sensing states would make data "available to interested States, international organizations, individuals, scientific communities and others on an equitable, timely and non-discriminatory basis." Although the current United States policy could exclude the sensing state from the non-discrimination requirement and could in theory permit earlier access to its nationals, the non-discrimination aspect suggests that the State Department may be tending away from policy choices--and hence institutional configurations--which would permit access to earth resources satellite data prior to complete circulation through the federal Landsat processing network.

Another potential disadvantage could arise from the fact that the United States usually bases its argument in favor of open dissemination on the fact that the Landsat program has made a vast amount of information available to states which otherwise would have had no opportunity to secure it. The

response has been, first, that NASA's current dissemination policy is entirely unilateral in nature and is therefore subject to unilateral alteration, and second, that the United States has not provided any assurance that the Landsat program will be continued on medium-term -- much less, a long-term -- basis. In its effort to secure a consensus on its open dissemination policy, the United States may feel compelled to commit itself to continuation of federally supported earth resources programs for the foreseeable future. The legislation introduced by Senator Ford to establish an operational earth resources satellite system under the control of NASA and the Department of the Interior would be consistent with that approach.[37] Because of reliance interests developed by other governments, a decision to utilize an organizational structure or selection of a means of distribution substantially different than the present method of selling partially refined data at the cost of reproduction is likely to subject the State Department to serious foreign pressure.

The third major element of current United States policy is the encouragement by sensing states of the broadest feasible international participation in appropriate phases of their respective programs. To facilitate that goal, the United States has proposed that sensing states should provide, within the limits of their capabilities, assistance to other interested states regarding the acquisition, interpretation and application of satellite-gathered earth resources data. The implication is that the United States government will continue encouraging other governments to participate in its Landsat program by

establishing national or regional ground stations and data interpretation facilities. Participation and technical assistance are likely to generate a dependence among other countries upon U.S. government programs, thus increasing the international pressure to continue or even expand the current programs. The scope of the assistance actually provided will determine the extent to which the combination of readily available data and essentially gratuitous transfer of applications expertise will jeopardize the viability of the international marketing activities. However, in light of United States foreign policy interests, the level of assistance is likely to become substantial.

Although the differences between the interests of the Carter Administration and those of previous administrations may cause some changes in present United States policy, a number of considerations are likely to diminish the magnitude of any policy shifts. First, the federal government has a number of interests which would be advanced by an open data dissemination policy enhanced by technical assistance efforts. The federal government is primarily interested in procuring the benefits of satellite remote sensing technology for its citizens. Among these benefits are increased supply of raw materials, increased information for managing the national economy and enhanced ability to monitor the national environment for

purposes of preventing or reversing environmental degradation. Consequently, the government is concerned that the policies it advocates will facilitate: a) effective, accurate service; b) on a real-time basis; c) at a reasonable cost.

A second primary interest is the selection of a combination of national and international policies which will develop the technology to operational status as soon as possible consistent with the realization of other goals. Third, the federal government is concerned that it reduce its expenditures as far as possible consistent with the achievement of other goals. The implications of this consideration are complicated by the fact that the government has a potential dual role as both provider and consumer of earth resources data services.

Fourth, federal policymakers are interested in expanding exports through satellite remote sensing in two ways. First, by promoting the international role of earth resources data and receiving and data processing equipment, the United States would improve its balance of payments and generate the foreign policy benefits discussed below. The federal government probably also intends to use earth resources satellite data at a second level as a tool, first, to develop previously underdeveloped food and mineral resources in order to increase supply and decrease world raw materials prices, and second, to encourage other states, especially the developing states, to use revenues from their increased volume of raw material exports to increase their imports, particularly from the United States. This broader approach seems to promise greater benefits for the

United States economy as a whole. That promise is increased by the apparent tendency of the American economy, *vis-à-vis* the economies of other countries, to specialize in the provision of information services. To maximize the benefits of the broader approach, access to earth resources data must be extended as far as possible.

Fifth, federal policy has traditionally enabled American private enterprise to exploit technology for commercial purposes, but the tendency has been limited by the extent to which other governmental interests have outweighed the interest in promoting commercial involvement.

In addition to those domestic policy factors, the United States has a wide range of foreign policy interests which could be affected by its choice of an international remote sensing policy. The first of those interests is the desire to continue reaping the benefits of other nations' recognition for United States technological leadership. To accomplish that goal, continued research and development is essential, indicating the need for continuing federal involvement in the earth resources field. Further, the United States must be able to demonstrate highly visible technical progress. On a more subtle level, these prestige benefits are also contingent on showing that the benefits of technological progress extend beyond the borders of the United States to less advanced countries.

The second set of foreign policy interests centers around the use of satellite remote sensing as a foreign policy tool.

If the U.S. government retains some measure of control over the allocation of earth resources data and services, it will be able to use the technology as a reward-or-punishment tool to advance its other foreign policy interests. Transfer of control to the private sector, however, would limit the flexibility of the tool.

The avoidance of foreign policy disadvantages could also militate against selection of a policy conducive to transfer to private enterprise. A profit-oriented organization is not likely to be especially concerned about the international political ramifications of the uses made of its work products by customers of refined earth resources data. Consequently, aggravation of international disputes could result particularly with regard to boundary placement in regions where satellite imagery indicates the existence of valuable natural resources Blame would fall on the United States, even if its system were not operated by the government. Government control could limit the adverse consequences.

Similarly, government control could limit the negative response sometimes generated by an aggressive profit-oriented applications program. Direct profits for the earth resources industry might be reduced, but the benefits to the whole economy might, as noted above, be greater over time. Concerns expressed in the United Nations regarding the potential for economic imperialism if earth resources satellites were operated by a single government or private entity may lead the State Department to favor some

inter-governmental arrangement designed to give at least the appearance of international control.

The third disadvantage to be avoided by non-private control of earth resources activities is the problem of international backlash which could result from transfer to the private sector. NASA has entered into a number of bilateral agreements with other governments for cooperation on earth resources satellite experiments. Each of those agreements calls for NASA to permit access to its Landsat system, and the other party agrees to construct an earth station and pay its own costs of participation. In addition, NASA has made attractive proposals which would encourage other states to invest in earth resources technology. In 1970, NASA proposed that the United States government adopt a program under which launching states would make data available to interested states at the cost of duplication, while a special United Nations facility would be established initially to service such United Nations agencies as the Food and Agriculture Organization (FAO) and the Economic and Social Council (ECOSOC), and later to assume such other responsibilities as were assigned to it by the world community.[38] Four years later, at the third session of the CPUOS Working Group on Remote Sensing, the United States offered to provide any international earth resources center with a master copy of the data collected during NASA's experimental ERTS program.[39] The agreements and offers by the United States combined with reliance by other states created international pressure on the federal government to continue providing some

level of Landsat services. Transfer of its responsibility to a private entity would eliminate such unprofitable services, probably causing a backlash among other states.

Achievement of all of the foreign policy goals and most of the other goals described above is dependent at least in part upon extensive international participation. Consequently, the combination of national and international policy choices by the United States are likely to be designed in such a way as to make it clear to foreign governments that participation in the proposed international system would substantially advance their respective national interests. A policy essentially transferring responsibility for earth resources satellite technology to the private sector would complicate the prospects for international participation.

In addition to its own interests, the State Department is likely to consider the interests of other federal agencies, most significantly NASA and the Department of Interior. In furtherance of NASA's statutory mandate to promote the widest feasible application of space technology on both the national and international levels, NASA and its Office of International Affairs are actively supporting continuation and expansion of the network of memoranda of understanding between NASA and foreign governments. Expansion of the network could generate increased international opposition to discontinuation of the international aspects of the Landsat programs. Further, proliferation of ground stations could

overcome some of the impediments to the establishment of an intergovernmental consortium, which could seriously limit the international market for commercial earth resources services. A policy of intergovernmental implementation on the international level would also strengthen the arguments for provision of earth resources services by a federal agency or federally chartered entity.

The Department of Interior and the U.S. Geological Survey are promoting a policy consistent with their proposals to improve and expand the Sioux Falls installation to facilitate transfer of data to both domestic and international customers. Increased federal involvement at that point in the Landsat system is likely to diminish the probability that private entities will be permitted access at an earlier point in the system.

Other elements, particularly from the academic community, are pressing for a U.S. policy in the United Nations which would make available throughout the world both earth resources data and the knowledge and hardware needed to apply the data. Those initiatives generally evidence a distrust of the commercial approach, particularly with respect to socially useful, but generally unprofitable applications.

The foregoing analysis of current trends in the CPUOS debates relating to principles to govern the use of earth resources satellites is relevant to general considerations in two main ways. First, under the definition of space industrialization set forth in Part I above, satellite remote sensing constitutes one of the four main categories. Second,

a comparison of trends in the direct broadcast and earth resources satellite debates indicates that common trends can be identified. Consequently, those trends and the underlying complex of national interests provides the basis for projection of related trends applicable to other types of space industrial activities. As described more fully in Part V below, tendencies apparent from the debate surrounding the draft principles discussed in Subsection B above, suggest that the majority of CPUOS delegations favors a relatively restrictive approach to the development of outer space. This trend, combined with parallel responses in the domestic policy making process, could lead to establishment of international principles which limit the range of available institutional options and hence the character of potential participants in space industrialization.

III. IMPLICATIONS FOR SPACE INDUSTRIALIZATION OF THE CPUOS DEBATES ON THE DRAFT MOON TREATY

The first initiative to establish international principles to govern the use and exploration of the moon occurred in 1970 when Argentina submitted a proposal to the United Nations calling for promulgation of appropriate rules.[1] However, significant activity in the United Nations in that area did not occur until the Soviet Union introduced a draft moon treaty in June 1971.[2] In response, the General Assembly directed the Committee on the Peaceful Uses of Outer Space (CPUOS) to consider and elaborate upon the Soviet draft treaty at its fourteenth session, held in New York in September 1971.[3] The Outer Space Committee referred the draft treaty to its Legal Sub-Committee for detailed consideration at its eleventh session in April and May 1972. Despite significant differences of opinion among the delegations, the subcommittee was able to formulate a unified negotiating text consisting of a preamble and twenty-one draft articles. However, certain provisions were stated in alternative forms, indicating disagreement among the delegations as to those provisions. As a result, consideration of the treaty was continued the following year.[4]

The Legal Sub-Committee again examined the draft moon treaty at its twelfth session in March and April 1973, and several working papers were submitted by various delegations. Six provisions were adopted by the Legal Sub-committee which modified the 1972 draft somewhat and focused the remaining disagreements

around three main issues:

1. scope of the treaty;
2. disposition of lunar resources; and
3. character and scope of information about the objectives of lunar missions to be made public prior to their commencement.

Since 1973 the same issues have remained unresolved and have prevented final approval of a moon treaty.

A. <u>Current Status of the Moon Treaty Debate</u>

Since 1973 three main issues have remained unresolved and prevented establishment of a final consensus on a draft moon treaty to be submitted to the General Assembly. The questions relating to the disposition of lunar resources are considered the most difficult, and its solution is expected to permit resolution of the remaining issues.[5]

1. *Natural Resources*

The main positions among CPUOS delegations on issues relating to the exploration and use of the moon are most clearly crystallized on the question of the disposition of lunar resources and its four major subissues:

1. the impact of Article II of the Outer Space Treaty;
2. the impact of the evolving concept of the common heritage of mankind;
3. the desirability of deferring regulation of lunar exploration and use until those activities have become imminent;

4. the desirability of declaring a moratorium on the exploitation of lunar resources pending establishment of an international consensus on the disposition of lunar resources.

For purposes of clarity, this discussion will consider the question of lunar resources from the perspective of these subissues.

a. Article II and National Appropriation of Lunar Resources

Since 1973 two main positions on the question of national appropriation of lunar resources have emerged. The United States takes the position that the Article II prohibition against appropriation of the moon and other celestial bodies does not prohibit acquisition of propriety rights in the natural resources of the moon.[6] They interpret Article II as prohibiting a state from exercising sovereignty over parts of the moon, but not prohibiting a state from gaining proprietorship over goods, including natural resources, which they take or "capture" from the moon.[7] This conceptual distinction between prohibited sovereignty and permitted proprietorship of natural resources is based on the provisions in Articles I and III of the Outer Space Treaty, which expressly permit states to "use" the moon.[8] As a result, those delegations argue that prohibition of ownership of the natural resources of the moon would require alteration of existing law as embodied in the Outer Space Treaty.

The Soviet position reaches the same conclusion by somewhat different reasoning. The Soviets advocate strengthening the Article II prohibition. In particular, they argue that the right of states to explore and use the moon, and the practical establishment of moon stations, does not create an ownership right to the surface or subsurface.[9] However, as made clear in the Soviet Draft Moon Treaty, the Soviets would expand and clarify Article II by expressly enumerating the entities to whom this prohibition allegedly applies. Under the Soviet approach, the prohibition would cover international organizations, private organizations, and individuals, as well as states.[10] However, the Soviet delegation argues that the Article II prohibition does not apply to natural resources, and that the rights to these resources for exploitation for either local moon requirements or for transportation to Earth are not defined in the Outer Space Treaty.[11] Both delegations agree that the status of the moon's natural resources should be determined in the moon treaty without any restrictions due to the ban on national appropriation in Article II of the 1967 Outer Space Treaty; instead, beneficial ownership of such resources would be given to those states that are actually making use of them.

The point of view espoused by the United States, the Soviet Union and other potential space powers is opposed by a bloc of developing countries, led by the delegation of Argentina. The Argentine position recognizes two classes of ownership.

The first, direct or eminent domain, is considered prohibited by Article II. The second, beneficial ownership (domain útil) is the enjoyment, receipt of the fruits and profit derived from property which is either unowned or commonly owned.[12] Because of their support of the principle of the common heritage of mankind, the developing countries maintain that lunar resources are owned in common by all members of the international community and is protected against national appropriation by the provisions of Article II.[13]

b. The Impact of the Concept of the "Common Heritage of Mankind"

Closely related to the issues surrounding application of Article II to lunar resources is the question of the applicability of the evolving concept of the "common heritage of mankind." Professor Aldo Armando Cocca, who heads the Argentine delegation, is the concept's leading advocate. In essence, the common heritage principle would secure beneficial ownership (domain útil) of lunar resources for all members of the international community. Consequently, if adopted, that concept would prevent individual states from appropriating lunar resources for individual use; instead, some form of sharing arrangement would be mandated. Such arrangements could require equitable allocation either of the resources extracted from the moon or of profits derived from the sale of these resources.

Professor Cocca admits that both negative and positive consequences are to be anticipated from granting beneficial ownership of the moon to all of the states. The projected

negative aspects -- including inhibition of commercial initiatives -- would affect only those countries which now have the capacity to reach outer space. However, Professor Cocca maintains that all states, including the space powers, will benefit from lunar development on that basis. In particular, Professor Cocca has identified the following specific benefits:

- -- a realization on the part of all States and peoples that they are entitled to the benefits derived from the principles and norms established for outer space and celestial bodies;
- -- the need to link to the exploration and use of space and celestial bodies the exploitation thereof;
- -- the search for profit, with an attempt to ensure its results;
- -- equitable sharing of profits derived,
- -- consideration of the needs and interests of developing countries,
- -- supervision of this activity with a view to equitable distribution;
- -- the institution of an international regime;
- -- the establishment of appropriate procedures for such regime, and
- -- the existence of international machinery or an international authority to give effect to all the expectations that have been voiced.[14]

The Soviet delegation has opposed the inclusion of the "common heritage" concept in the draft moon treaty because it provides in effect for common ownership of lunar resources, which conflicts with the Soviet position, first, that no property interest should be created prior to the time the minerals are extracted from the moon's surface or subsurface,

and second, that upon extraction, beneficial ownership should vest in the entity undertaking the mining operation. The underlying rationale is that since the Outer Space Treaty forbids national appropriation, the term "heritage," which is essentially a property concept, should not be used in the moon treaty because it goes far beyond the "common province of all mankind" language sanctioned in the Outer Space Treaty.[15] Soviet commentators add that the movement to incorporate the concept into the law of the sea is a serious hindrance to the completion of moon treaty negotiations adoption because of the variances between national interests with respect to ocean resources and corresponding interests on the moon.[16]

Although the United States is opposed to incorporation of the concept into the moon treaty, it has not taken a strong stand against the "common heritage" concept.[17] The United States has taken the position that it will accept inclusion of the phrase only if it is defined as not carrying any expressed or implied prohibition of exploitation of the moon's natural resources.[18] The United States will support an equitable sharing of the benefits of such exploitation, but only if such sharing is defined as allowing expenses of the space program to be deducted before the benefits are shared. The United States bases this position in equity by reasoning that if it were otherwise, a nation would carry the financial burden of space exploration without offsetting this burden with the benefits.[19]

Other delegations including Hungary and Czechoslovakia, have taken a compromise position which would specifically provide that the main goal is to obtain the benefits of outer space for the benefit of all, but this will not be accomplished unless those countries carrying the expensive burden of space exploration are reimbursed with a certain degree of profit.[20]

At present the status of the concept under international law is subject to extensive debate.[21] Continued lack of opposition in the CPUOS negotiations is likely to combine with parallel developments in other areas, most notably the law of the sea, to permit evolution of the concept into a binding principle of international law. If the "common heritage" principle were applied generally to space industrial activities, private initiatives may never become economically viable.

C. Desirability of Deferring Disposition of Lunar Resources

As part of the position of potential space powers that restrictive principles should not be applied to lunar resources, it is argued that at present the technology and operational institutional arrangements are not sufficiently developed to permit effective policy planning, and that premature restriction of lunar development activities would defer or prevent realization of the benefits likely to be available from exploitation of lunar resources. This approach is paralleled by arguments primarily made by the United States in the context of the earth resources and direct broadcast satellite debates. Virtually all of the delegations concede that the establishment of legal principles governing the moon's natural resources may be pre-

mature because technology is not sufficiently advanced to provide a sound, practical basis for such principles.[22] Nonetheless, representatives from the developing countries have urged resolution of the lunar resources issue before it is complicated by investment and reliance interests are created.[28]

d. Desirability of Imposing a Moratorium on Lunar Development Pending Resolution of the Natural Resources Issue

As an element of the "common heritage" position, the developing nations want to impose a moratorium in regard to any development and exploitation of resources on the moon until an international arrangement is made, under which all countries will directly participate in or benefit from such development and exploitation.[24] In response to the prematurity arguments discussed above, the developing nations point to the paradox that at present it is too early to elaborate upon the space legal principle governing the moon and its exploitation because technology is not sufficiently advanced, and in the future it will be too late to do such elaboration because a de facto situation will already exist.[25] The solution to the dilemma, it is argued is a moratorium on development until appropriate policy guidelines are formulated.

The space powers and other industrialized nations maintain that such a moratorium would discourage any country from carrying on any program designed to investigate even the possibility of commercial use of lunar resources, and would eliminate any incentive for the development of the technology required

for exploration and development. The practical effect would not be to encourage the next logical stage in lunar exploration or, if the scope of the treaty is broadened, in the exploration of other celestial bodies.[26] For that reason, the United States in particular is strongly opposed to any sort of moratorium. One U.S. commentator has argued that the moon treaty should be structured to promote rather than delay exploitation.[27] This comment is particularly incisive because it highlights a fundamental policy question referred to previously in the discussions of international direct broadcast and earth resources satellite policy, the choice between rapid operational implementation and full-scale international participation. The resolution of this question for each new technology or space activity will influence the viability of commercial entry.

2. *Scope of the Moon Treaty*

The second major unresolved issue centers upon the scope of the proposed treaty. On one hand, the original initiatives in this area were focused specifically on the moon. However, others have argued that the treaty should cover "the Moon and other celestial bodies" in accordance with the language of the 1967 Outer Space Treaty.[28] The former position is taken primarily by space powers who wish to avoid establishment of any restrictions on exploration of other celestial bodies, and the latter is taken by Argentina and the developing countries, which are attempting to establish the "common heritage" approach

in as many new areas as possible. However, despite the divergent interests of the two blocs, resolution of the natural resources issue is likely to incorporate a solution for this issue as well. The most likely compromise will limit the express scope of the treaty to the moon, but permit arguments by analogy regarding the management of other celestial bodies until more specific international instruments are approved.

3. *Prior Information*

The final unresolved issue relating to the draft moon treaty concerns the nature and scope of information each state will be required to furnish prior to the commencement of lunar missions. The positions on this issue do not follow the divisions identified on the other two issues.

The Soviet delegation argues that states should not be required to provide prior information concerning their missions because the 1967 Outer Space Treaty already establishes appropriate criteria for the exchange of information, and anymore stringent requirement would require alteration of existing law and would amount to an attempt to interfere in the domestic affairs of each launching state. The latter contention is based on the notion that mandatory advance notification implicitly contains the right of other states to express protest.[29]

In contrast, the United States supports advance notification on the grounds that it would avoid duplication and stimulate scientific efforts.[30]

The developing nations support very thorough and wide ranging prior dissemination of information. India has even proposed in one of its working papers to the Legal Sub-Committees that all nations be obligated to share discoveries of natural resources (which is not currently required in the draft treaty).[31] The delegation from Bulgaria, which is one of the leading advocates of compromise on all three unresolved issues of the Draft Moon Treaty, suggests that the point in time to require all states to give information concerning moon missions is "as soon as possible after launching." Compromise on that basis appears possible which will develop on this issue.[32]

B. Prospects for Resolution of the Moon Treaty

In contrast to the CPUOS debates on direct broadcast and earth resource satellites, the United States and the Soviet Union have taken similar positions on the issues raised by the draft moon treaty, in particular on the key question of the disposition of lunar resources. Both of the major space powers, as well as a number of the states which are presently developing space capabilities have perceived their interests to be best served by postponing the resolution of the issue of the legal status of the natural resources of the moon, if agreement can only be based on a "common heritage" approach which deprive the space powers of a very valuable advantage with respect to the exploitation of those resources.

The developing nations have perceived delay to be contrary to their interests. They also are aware that their demand to include the "common heritage" language is one of the main impediments to establishment of an international consensus on principles to govern the exploration and exploitation of the moon's resources. As a result, some significant pressure to soften demands for incorporation of "common heritage" language is being exerted. However, since the less developed countries are seeking to establish "common heritage" regimes in a number of areas, including the deep seabed, they are unlikely to soften these demands to any significant degree. Consequently, rapid resolution of the CPUOS negotiations on the draft moon treaty is unlikely. In the absence of a major policy initiative proposing mutually agreeable resolution of a number of diverse issues, protracted negotiations may be anticipated. The United Nations conference on science and technology proposed for 1979 may provide a framework for such an initiative.

PART IV: CONCLUSIONS

The foregoing analysis raises a fundamental question relating to the extent to which and the conditions under which the private sector will be permitted to participate in the development of outer space. On one hand, in some cases in the United States the responsibility for operational implementation has been left to the private sector. The most significant example is the case of communications satellite technology. On the other hand, current trends are leading away from significant private sector participation. Consequently, the private sector should be concerned that its option to participate may be eroded.

Assumption by the private sector of responsibility for operational activities suggests a wide range of potential benefits for national interests. First, commercial enterprises are likely to promote institution and provision of full-scale, high quality operational services on a more timely and efficient basis than any of the other institutional alternatives. Second, commercial implementation would permit the federal government to focus its efforts on appropriate research and development activities. That approach gives rise to three advantages. First, the combination of government research and private sector implementation has proven highly effective in maximizing the realization of the potential benefits of technological development. Second, concentration of federal efforts on research and development will result in minimization of federal

expenditures consistent with optimum technological development. Third, private sector implementation would make the system operation and service offerings responsive to marketplace demand rather than the congressional budgetary cycle, with concomitant positive implications for the quality and consistency of service.

Another advantage from private sector operation of mature systems is based on the positive effects for national economic development. Although any other institutional approach may promote economic development, commercial implementation is more likely to maximize the multiplier effects throughout the national economy.

These and other considerations suggest that private sector participation in space operations is desirable. Nonetheless, a number of trends suggest that national and international policy may be moving away from promotion of full-scale commercial involvement. On the national level, that tendency is evidenced, for example, by the legislative trends. In August 1976, Senator Moss introduced a bill to establish an operational earth resources satellite system based on private sector initiatives. In January of this year, Senator Ford introduced a related bill which removed the private sector mandate, allocating operational responsibility to NASA and to the Department of the Interior.

A number of parallel trends are apparent in the international arena. Even the cornerstone of international space

law, the 1967 Outer Space Treaty, creates the foundation for limitation of private sector involvement. Article I(1) is said to require space activities to be carried out "for the benefit and in the interests of all countries." If any operative effect is given to that phrase, it could diminish the viability of commercial ventures. Similarly, Articles VI and VII of the Outer Space Treaty, as well as the Convention on International Liability for Damage Caused by Space Objects contain provisions which potentially require relatively restrictive governmental supervision of national -- including commercial -- space operations. Supervision is likely to entail regulation and resultant limitation of operational flexibility.

Of course, the treaty's provisions as interpreted by the United States are not completely negative. For example, Article II arguably does not inhibit appropriation of outer space or portions of celestial bodies by private enterprises. However, this construction is not universal. As noted in Section III of Part III above, the Soviets interpret Article II to prohibit appropriation by any entity, including commercial entities. In addition, a number of current trends suggest that private sector involvement in the implementation of new space technologies will not be encouraged. First, negotiations presently underway generally do not take private sectors interests sufficiently into account. In addition to actions relating to the adoption of the potentially restrictive principles discussed above in Sections I-III of Part III,

specific efforts have been made to preclude private sector participation in both direct broadcasting and satellite remote sensing. The reasons for these tendencies appear to be three-fold. First, the negotiations are conducted between governments, and most delegations do not have national private sector interests in space development to protect, and as a result, advocate policies which protect national interests rather than promote commercial development. Second, negative attitudes toward international commercial ventures motivates even space powers to place concern regarding international repercussions above national commercial interests. Finally, private sector interest in participating in operational space activities has been somewhat understated, possibly because of the low level of market development.

The lack of emphasis on private sector interests in international negotiations is complicated by the demands of less developed countries to treat space and other resources as the "common heritage of mankind." The trend toward mandatory licensing of activities relating to the exploitation of seabed resources may be extended to the moon and other celestial bodies. The allocation of geostationary orbital slots by the ITU according to an _a priori_ plan rather than actual use is another indication of the trend in this direction.

Paralleling the evolution of the "common heritage" concept is a tendency toward international policies mandating international participation and sharing. At present, the trend is

evident in proposals relating to direct broadcast and earth resources satellite activities. The "common heritage" approach to disposition of lunar resources is conceptually similar. This trend could lead eventually to sharing of facilities, space vehicles, products, and perhaps even profits of space ventures. Private sector participation could be jeopardized by any of those results.

Although there is ample evidence to support the existence of these tendencies, their strength should not be overestimated. First, the current series of CPUOS negotiations has been in progress for a number of years, and final resolution of outstanding issues is not expected for some time. Until those negotiations are completed, direct impact on space activities is likely to be somewhat limited. Second, as institution of operational services becomes imminent, some shifts away from restrictive political positions toward more practical, results-oriented approaches may occur. Consequently, the trends described above are likely to be reversible under appropriate conditions. From the perspective of the private sector, a thorough evaluation of this possibility appears desirable, in light of the possibility that advances in space technology may create attractive business opportunities.

To maximize effectiveness, the suggested approach should focus on the development of an ability to respond to legal, institutional and policy developments which will either affect particular space industrial activities directly or create

precedents which will influence future policy decisions. Since space services are likely to affect both national and international interests, the scope of this approach should encompass both sets of considerations. In addition to the international deliberations described in the present memoradnum which are likely to influence the nature and scope of international activity, national policymaking activities are currently underway, especially in the earth resources and direct broadcast areas, which are likely to affect private sector interests in a number of space industrial activities. The most significant example is the legislation introduced in the Senate to establish an operational earth resources satellite system. In order to preserve its option to participate in the development of outer space, the private sector should develop the ability to respond to significant initiatives or trends.

This response cabability should be based on adequate information. Consequently, effective monitoring activities are considered desirable. The objectives of those activities should be to identify:

1. significant interests affected by each category of space industrial activity;
2. main actors, both institutions and individuals;
3. main policy considerations; and
4. key decision points.

To achieve the necessary level of effectiveness, monitoring should be conducted on a systematic, on-going basis.

However, a systematic approach is difficult because of the broad array of material considerations. Consequently, a means of selecting monitoring activities to provide both manageability and accuracy must be developed. There are management tools which permit a comprehensive view of the process of developing a technology from initial experimentation through operational implementation. Such a framework could facilitate identification of key activities and trends and could provide the basis for anticipating and responding to developments relevant to future space industrial efforts.

FOOTNOTES

PART 1: THE CONCEPT OF SPACE INDUSTRIALIZATION

1. For a discussion of the NASA communication satellite experimentation, *see generally* D. Smith, *Communication Satellite User Experimentation. A Technology in Transition* (to be published in 1977).

2. *See* Sections I.A and I.B. in Part II below.

3. *See*, *e.g.*, Environmental Research Institute of Michigan, *Proceedings of the International Symposia on Remote Sensing of the Environment* (1975 and preceding years); *Proceedings of the NASA Earth Resources Survey Symposium*, Houston, Texas (June, 1975); NASA, Office of Applications, *The Space Applications Program 1974* Ch. 3; National Academy of Sciences, National Research Council, *Resource and Environmental Surveys from Space with the Thematic Mapper in the 1980s* (1976), General Electric Space Division, *Definition of the Total Earth Resources System for the Shuttle Era* (NASA Contract NAS 9-13401) (March 1975).

4. For a more complete listing of potential products, *see*, e.g., National Academy of Sciences, Space Applications Board, *Practical Applications of Space Systems*, Supporting Paper No. 9, "Materials Processing in Space" (1975); "NASA Seeks Industry Space Processors," *Aviation Week and Space Technology*, January 26, 1975, at 46-61.

PART II: INTERNATIONAL AGREEMENTS APPLICABLE TO SPACE INDUSTRIALIZATION

1. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, January 27, 1967, [1967] 18 U.S.T. 2410, T.I.A.S. 634, 610 U.N.T.S. 205, entered into force for the United States on October 10, 1967 [hereinafter referred to as the Outer Space Treaty]. The materials in Part II are adapted in part from D. D. Smith, "The Status of Solar Power Systems under International Space Law," March 9, 1977.

2. Convention on International Liability for Damage Caused by Space Objects, March 29, 1972, 24 U.S.T. 2389, T.I.A.S. 7762, entered into force for the United States on October 9, 1973.

I. TREATY ON PRINCIPLES GOVERNING THE ACTIVITIES OF STATES IN THE EXPLORATION AND USE OF OUTER SPACE, INCLUDING THE MOON AND OTHER CELESTIAL BODIES

1. See the discussion of the "peaceful uses" requirement below the text of the present section accompanying footnotes in Section I.A.2.

2. M. Markoff, Disarmament and "Peaceful Purposes" Provisions in the 1967 Outer Space Treaty, 4 Journal of Space Law 3, 12 (1976).

3. P. Dembling and D. Arons, The Evolution of the Outer Space Treaty, 33 Journal of Air Law and Commerce 419, 429-30 (1967), and authority cited there.

4. Markoff, supra note 2, at 13-14, M. Markov, Implementing the Contractual Obligation of Art. I, Par. 1 of the Outer Space Treaty of 1967, in Proceedings of the Seventeenth Colloquium on the Law of Outer Space 136, 137 (1976), M. Dauses, The Relative Autonomy of Space Law, in Proceedings of the Eighteenth Colloquium on the Law of Outer Space 75, 79 (1976).

5. See E. Fasan, Utilization of Energy From Space -- Some Legal Questions, in Proceedings of the Eighteenth Colloquium on the Law of Outer Space 2, 3 (1976).

6. M. Markov, Implementing the Contractual Obligation of Art. I, Par. 1 of the Outer Space Treaty of 1967, in Proceedings of the Seventeenth Colloquium on the Law of Outer Space 136, 137-138 (1975).

7. See, e.g., Treaty on Remote Sensing of Natural Resources by Means of Space Technology: Draft Basic Articles, Submitted jointly by Argentina and Brazil, U.N. Doc. A/C.1/1047 (1974), arts. VII, VIII, XI and XII, Working Paper Submitted by France to the Second Session of the Working Group on Direct Broadcast Satellites, U.N. Doc. A/AC.105/62, June 30, 1969.

8. See, e.g., Markov, supra note 6, at 137-38.

9. See Revised Single Negotiating Text, Third United Nations Conference on the Law of the Sea (1976), Part I.

10. See the discussion of the direct broadcast satellite controversy in the United Nations in Part III, Section I, below.

11. See the discussion of the earth resources satellite controversy in the United Nations in Part III, Section II, below.

12. E.g., M. Markoff, Disarmament and "Peaceful Purposes" Provisions in the 1967 Outer Space Treaty, 4 Journal of Space Law 3-22 (1976); M. Markoff, Implementing the Contractual Obligation of Art. I, Par. 1 of the Outer Space Treaty of 1967, in Proceedings of the Seventeenth Colloquium on the Law of Outer Space 136, 139 (1975); M. Niciu, What is the Meaning of the Use of Cosmos Exclusively for Peaceful Purposes, in id., at 224, 228.

13. The validity of this assumption is central to the subject matter of Section I.D. below and is examined more fully there.

14. See, e.g., Markoff, supra note 12, at 6-8; M. Dauses, The Relative Autonomy of Space Law, in Proceedings of the Eighteenth Colloquium on the Law of Outer Space 75, 78-79 (1976).

15. See authorities cited in footnote 12.

16. Markoff, supra note 12, at 21.

17. See id., at 11.

18. Niciu, supra note 12, at 299.

19. Markoff, _supra_ note 12, at 10.

20. _Id._, at 7.

21. _Id._

22. The Treaty Prohibiting the Placing of Any Nuclear and Other Kinds of Weapons of Mass Destruction on the Sea and Ocean Bed as well as in Their Subsoils, adopted in U.N.G.A. Resol. 2660 (XXV) on December 7, 1970, establishes the principle that certain areas shall be used exclusively for peaceful purposes.

    Article 2 of the United Nations Convention on the High Seas, [1962] 13 U.S.T. 2312, T.I.A.S. No. 5200, 45 U.N.T.S. 72 (in force September 30, 1964), lists four specific freedoms of the high seas and continues:

    > These freedoms, and others which are recognized by the general principles of international law, shall be exercised by all states with reasonable regard to the interests of other states in their exercise of freedom of the high seas.

    The right to mine the seabed of the high seas is one of those "other" freedoms. In its 1950 and 1951 Reports, the International Law Commission specifically listed mineral exploitation as one of the freedoms of the sea. _See_ Laylin's comment in "Discussion," _The Law of The Sea, Needs and Interests of Developing Countries_ 51 (L. Alexander ed. 1972). Although it was not specifically listed in later drafts, there is no evidence that the Commission rejected the concept as a high seas freedom. For that reason, mineral exploitation must be considered one of the "other" freedoms. Moreover, the High Seas Convention itself implicitly recognized the right to exploit the seabed when it provides for preventing pollution from such activity. Article 24 states: "Every state shall draw up regulations to prevent pollution of the seas * * * resulting from the exploitation and exploration of the sea-bed and its subsoil * * *."

23. The legality of placing such installations or weapons systems in orbit is considered below in Section I.D.

24. _See, e.g._, B. Dudakov, International Legal Problems in the Use of the Geostationary Orbit, in _Proceedings of the Fifteenth Colloquium on the Law of Outer Space_ 71 (1973).

25. G. Reintanz, Some Remarks on Space Activities Which May Have Harmful Effects on the Environment, in _Proceedings of the Fifteenth Colloquium on the Law of Outer Space_ 277, 278 (1973); B. Dudakov, International Legal Problems in the Use of the Geostationary Orbit, in _id._, at 71-72.

26. S. Gorove, Interpreting Article II of the Outer Space Treaty, 37 Fordham Law Review 349 (1969). Professor Gorove adds a fourth issue relevant to general interpretation, namely whether any exercise of sovereign authority, use or occupation is permissible despite the prohibition of Article II. Id.

27. Dembling and Arons, supra note 3, at 431, E. Galloway, The Future of Space Law, in Proceedings of the Nineteenth Colloquium on the Law of Outer Space 2, 3 (1977).

28. Gorove, supra note 26, at 350.

29. The question of the applicability of Article II to the extraction of minerals is discussed further in Section III of Part III below.

30. Projected dimensions range from 11.73 kilometers in length and 4.33 kilometers in width, AIAA Technical Committee on Electric Power Systems, Solar Energy for Earth: An AIAA Assessment 61 (1975),.to 18.41 kilometers by 7.01 kilometers, G. F. von Thiesenhausen, Photovoltaic and Thermal Energy Conversion for Solar Powered Satellites, International Astronautical Federation Paper No. IAF-76-117 (1976), at 3.

31. See, e.g., Convention on the Continental Shelf, 499 U.N.T.S. 311 (1964), art. 5(3).

32. Gorove, supra note 26, at 352.

33. E.g., W. von Kries, Legal Status of the Geostationary Orbit, in Proceedings of the Eighteenth Colloquium on the Law of Outer Space 27, 30 (1976).

34. Dudakov, supra note 25, at 71, Comment, Utilization of the Geostationary Orbit -- A need for Orbital Allocation, 13 Columbia Journal of Transnational Law 98, 100-101 (1974).

35. E.g., G. Hazelrigg, The Economic Viability of Pursuing a Space Power System Concept, American Institute of Aeronautics and Astronautics Paper No. 77-353 (1977) at 1; Peter E. Glaser, Perspectives on Satellite Solar Power, American Institute of Astronautics and Aeronautics Paper No. 72-352 (1977), at 11 (hereinafter cited as Glaser, Perspectives].

36. Gorove, supra note 26, at 351.

37. Gorove, The Outer Space Treaty, 23 Bulletin of Atomic Scientists 44, 45 (1967).

38. W. Jenks, Space Law 201 (1965).

39. Gorove, supra note 26, at 351-52.

40. United Nations Charter, art. 51.

41. Q. Wright, Legality of Intervention under the United Nations Charter, 1957 Proceedings of the American Society of International Law 79, 82-83; J. Brierly, Law of Nations 415 (6th ed. 1963); Oppenheim, 2 International Law 15 (H. Lauterpacht, ed., 7th ed. 1952).

42. W. Friedman, Intervention, Civil War and the Role of International Law, 1965 Proceedings of the American Society of International Law 69; Roling, International Law and the Maintenance of Peace, 4 Netherlands Yearbook of International Law 1 (1973); H. Lauterpacht, The Boycott in International Relations, 14 British Yearbook of International Law 125, 130, 139 (1933), Hyde, 2 International Law, Chiefly as Interpreted and Applied by the United States, 185-86 (1965).

43. E.g., Glaser, Perspectives, supra note 35, at 8.

44. E.g., id., at 3.

45. E.g., AIAA Technical Committee on Elective Power Systems, Solar Energy for Earth. An AIAA Assessment 69 (1975).

46. Article V of the 1967 Outer Space Treaty relating to the rescue and return of astronauts is not directly relevant to the consideration of legal aspects of space industrialization.

47. P. Dembling and D. Arons, The Evolution of the Outer Space Treaty, 33 Journal of Air Law and Commerce 419, 436 (1967).

48. Id., at 437.

49. S. Estrade, The Utilization of Space as a Source of Energy for the Earth, in Proceedings of the Eighteenth Colloquium on the Law of Outer Space 7, 11 (1976).

50. Convention on International Liability for Damage Caused by Space Objects, March 29, 1972, 24 U.S.T. 2389, T.I.A.S. 7762, entered into force for the United States on October 9, 1973. For a discussion of the impact that the Liability Convention is likely to exert on space industrialization, see Section II of Part II below.

51. <u>See</u>, <u>e.g.</u>, Glaser, Perspectives, <u>supra</u> note 35, at 8-10, AIAA Technical Committee on Electric Power Systems, <u>supra</u> note 30, at 69.

52. Dudakov, <u>supra</u> note 25, at 71-72.

53. Dembling and Arons, <u>supra</u> note 47, at 441.

54. For a discussion of the scope and content of the consultation provisions, <u>see</u>, <u>e.g.</u>, J. Sztucki, International Consultations and Space Treaties, in <u>Proceedings of the Eighteenth Colloquium on the Law of Outer Space</u> 166-200 (1976), I. Herczeg, Provisions of the Space Treaties on Consultation, in <u>Proceedings of the Seventeenth Colloquium on the Law of Outer Space</u> 141-146 (1975).

55. Dembling and Arons, <u>supra</u> note 47, at 441.

56. <u>See</u> Section I.A.1. above.

57. <u>See</u> the text accompanying footnote 51.

58. J. Sztucki, International Consultations and Space Treaties, in <u>Proceedings of the Eighteenth Colloquium on the Law of Outer Space</u> 166, 180 (1976).

59. <u>Id</u>., at 183.

60. <u>Id</u>., at 177.

61. <u>Id</u>.

62. <u>E.g</u>., <u>id</u>., at 169, 174.

63. Id., at 184. However, when consultations fail to achieve the desired results, resort to the provisions of Chapter 6 of the United Nations Charter may be appropriate. I. Herczeg, Provisions of the Space Treaties on Consultation, in <u>Proceedings of the Seventeenth Colloquium on the Law of Outer Space</u> 141, 145 (1975).

64. Sztucki, <u>supra</u> note 58, at 183.

65. Herczeg, <u>supra</u> note 63, at 143.

II. CONVENTION ON INTERNATIONAL LIABILITY FOR DAMAGE CAUSED BY SPACE OBJECTS

1. For a summary of the CPUOS activities in relation to the Convention, see Senate Committee on Aeronautical and Space Sciences, Convention on International Liability for Damage Caused by Space Objects: Analysis and Background Data 92d Cong., 2d Sess., 8-10 (1972) (hereinafter cited as Senate Committee Report).

2. Convention on International Liability for Damage Caused by Space Objects, March 29, 1972, 24 U.S.T. 2389, T.I.A.S. 7762 (hereinafter referred to as Liability Convention).

3. Senate Committee Report, supra note 1, at 23-24.

4. See, e.g., Glaser, Perspectives, supra note 1, at 8-10; AIAA Technical Committee on Electric Power Systems, Solar Energy for Earth: An AIAA Assessment 69 (1975); P. Sand, Space Programs and International Environment Protection, in Proceedings of the Fourteenth Colloquim on the Law of Outer Space 79, 80-85 (1972); F. Zwicky, Examples of Activities in Extraterrestrial Space Which Might be Judged Harmful, Harmless, Useful or Either One of These, Depending on the Viewpoint, in Proceedings of the Fifteenth Colloquium on the Law of Outer Space 259-266 (1973); I.H. Diederiks-Verschoor, The Legal Aspects of Space Activities with Potentially Harmful Effects on the Earth and Space Environments, in id., at 268, 269-71.

5. See, e.g., S. Gorove, Some Comments on the Convention on International Liability for Damage Caused by Space Objects, in Proceedings of the Sixteenth Colloquium on the Law of Outer Space 253 (1974); J. Rajski, Convention on International Liability for Damage Caused by Space Objects -- An Important Step in the Development of the International Space Law, in Proceedings of the Seventeenth Colloquium on the Law of Outer Space 245 (1975).

6. Gorove, supra note 5, at 253.

7. Id., at 253-54.

8. See Section II.B. below.

9. See I. Diederiks-Verschoor, The Convention on International Liability Caused by Space Objects, in Proceedings of the Fifteenth Colloquium on the Law of Outer Space 96, 97 (1973).

10. Senate Committee Report, *supra* note 1, at 25.

11. Diederiks-Verschoor, *supra* note 9, at 97.

12. Senate Committee Report, *supra* note 1, at 25.

13. Under the absolute liability approach, the demonstration of those elements by a preponderance of the credible evidence would be sufficient to establish liability. However, the question has been raised whether a simple allegation or the relative probability of the existence of a causal relationship is sufficient. *See, e.g.*, I. Herczeg, Some Problems of the Convention on Liability Arising from Space Activities, in *Proceedings of the Fifteenth Colloquium on the Law of Outer Space* 111, 112 (1973).

14. Diederiks-Verschoor, *supra* note 9, at 97.

15. Senate Committee Report, *supra* note 1, at 26; I. Herczeg, *supra* note 13, at 113.

16. N. Poucantzas, Some Remarks on the Convention on International Liability Caused by Space Objects, in *Proceedings of the Fifteenth Colloquium on the Law of Outer Space* 130, 131 (1973).

17. Senate Committee Report, *supra* note 1, at 27.

18. *Id.*, at 27-28.

19. Herczeg, *supra* note 13, at 113.

20. Senate Committee Report, *supra* note 1, at 29.

21. Rajski, *supra* note 5, at 250.

22. *Senate Committee Report*, *supra* note 1, at 31.

23. Diederiks-Verschoor, *supra* note 9, at 101.

24. *E.g.*, W. W. Bishop, *International Law* 631 (1962) and authorities cited there in note 12, M. Sorensen, ed., *Manual of Public International Law* 575 (1968).

25. *E.g.*, Sorensen, *supra* note 24, at 582-84.

III. INTERNATIONAL TELECOMMUNICATION CONVENTION AND ITU RADIO REGULATIONS

1. International Telecommunication Convention (Torremolinos-Malaga 1973), entered into force, January 1, 1975.

2. The Convention and Radio Regulations also play a significant role in the allocation of the electromagnetic spectrum and would therefore affect the communications activities related to the industrialization of outer space. However, the effect of the Convention and Radio Regulations on communications is beyond the scope of the present memorandum.

3. See Sections I.A., I.B., and I.H. in Part II above.

4. J. Busak, Geostationary Satellites and the Law, 39 Telecommunications Journal 487 (1972) and authority cited there.

5. See, e.g., Comment, Utilization of the Geostationary Orbit -- A Need for Orbital Allocation, 13 Columbia Journal of Transnational Law 98, 103n. 30 (1974).

6. For an excellent discussion of the characteristics, capacity and technical considerations affecting the use of the geostationary orbit, see J. Gehrig, Geostationary Orbit -- Technology and Law, in Proceedings of the Nineteenth Colloquium on the Law of Outer Space 267, 268-272 (1977).

7. See Partial Revision of the Radio Regulations, Geneva, 1959, Nov. 8, 1963, [1964] 1 U.S.T. 887, T.I.A.S. No. 5603.

8. Comment, supra note 5, at 101; and Partial Revision of the Radio Regulations, supra note 7, arts. 5, 9A.

9. E. Valters, Perspectives in the Emerging Law of Satellite Communications, 5 Stanford Journal of International Studies 53, 76-77 (1970).

10. Comment, supra note 5, at 102.

11. Id., at 104.

12. Id., at 107. For a summary record of the 1971 WARC-ST, see "The World Administrative Radio Conference for Space Telecommunications," 38 Telecommunications Journal 673-82 (1971).

13. In its revised form, Article 9A provided:

> Section I. Procedure for the Advance Publication of Information on Planned Satellites Systems
> (1) An administration (or one acting on behalf of a group of named administrations) which intends to establish a satellite system shall, prior to the co-ordination procedure in accordance with No. 639 AJ where applicable, send to the International Frequency Registration Board not earlier than five years before the date of bringing into service each satellite network of the planned system, the information listed in Appendix 1B.
> Section II. Co-ordination Procedures to be Applied in Appropriate Cases
> (1) Before an administration notifies to the Board or brings into use any frequency assignment to a space station on a geostationary satellite or to an earth station that is to communicate with a space station on a geostationary satellite, it shall effect co-ordination of the assignment with any other administration whose assignment in the same band for a space station on a geostationary satellite or for an earth station that communicates with a space station on a geostationary satellite is recorded in the Master Register, or has been co-ordinated or is being co-ordinated under the provisions of this paragraph. For this purpose, the administration requesting co-ordination shall send to any other such administration the information listed in Appendix 1A.

Final Acts of the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971.

14. Regarding the role of the ITU and the IFRB in the management of the radio spectrum, _see_ Comment, The Role of the International Telecommunications Union in the Settlement of Harmful Interference Disputes, 13 _Columbia Journal of Transnational Law_ 82-97 (1974); D. Smith, _International Telecommunication Control_ 29-35 (1969); D. Leive, Regulating the Use of the Radio Spectrum, 5 _Stanford Journal of International Studies_ 21, 26-39 (1970).

15. Busak, _supra_ note 4, at 480.

16. Gehrig, _supra_ note 6, at 273.

17. _See_ Busak, _supra_ note 4, at 489.

18. Comment, _supra_ note 5, at 107.

19. Comment, supra note 5, at 103 n. 33.

20. W. von Kries, Legal Status of the Geostationary Orbit, in Proceedings of the Eighteenth Colloquium on the Law of Outer Space 27, 33 (1976).

21. The agenda for the WARC-BS is reported in "Broadcasting Satellite Conference," 43 Telecommunications Journal 703 (1976), see also ITU Broadcasting Satellite Conference, Document No. 181-E submitted by Austrialia, January 31, 1977, at 1.

22. U.N. Doc. A/C.1/PV.2049, October 13, 1975, at 43-46.

23. See ITU Broadcasting Satellite Conference Paper No. 229-E submitted by Ecuador, February 4, 1977, at 1.

24. "Meeting of the CCIR Study Groups Joint Working Party for the 1977 WARC-BS (12 GHz Band), 43 Telecommunications Journal 613, 614 (1976).

25. Id.

26. "WARC: it appears 'basic interest' was protected," Broadcasting, February 21, 1977, at 71-72.

27. The agenda of any WARC may be changed in accordance with Nos. 219-221 of the International Telecommunication Convention.

28. "31st Session of ITU Administrative Council," 43 Telecommunication Journal 565 (1976).

29. See the text accompanying notes 13-14 above.

30. For a comprehensive discussion of these experiments, see D. Smith, Communication Satellite User Experimentation. A Technology in Transition Chs. 8 and 9 (to be published in 1977).

31. See, e.g., "NASA Administrator and Japanese space officials meet," 42 Telecommunications Journal 48 (1975); "Japan Satcom design contract," in id., at 363.

32. A. Wheelon, "How Worldwide Communication Satellite Services Will Expand in Next Decade," Communication News, January 1976, at 16.

33. Id., at 17.

34. Id.

PART III FOOTNOTES

I. IMPLICATIONS OF THE CPUOS DEBATES ON DIRECT SATELLITE BROADCASTING FOR SPACE INDUSTRIALIZATION

1. For a comprehensive discussion of the ATS and CTS programs, see, D. Smith, Communication Satellite User Experimentation: A Technology in Transition Chs. 3-9 (to be published in 1977). The materials in Part III are adapted in part from D. Smith, Communication Via Satellite: A Vision in Retrospect (1976) Ch. 9.

2. American Society of International Law, Panel on International Telecommunications Policy, Direct Broadcasting from Satellites: Policies and Problems 9 (1974).

3. G.A. Res. 2453 (B), 23 U.N. GAOR Supp. 18, at 10-11, U.N. Doc. A/7218 (1968). For a history of the CPUOS direct broadcast debates, see D. Smith, Communications Via Satellite. A Vision in Retrospect Ch. 8 (1976). Excerpts of that chapter are used here by permission of A.W. Sijthoff Company.

4. U.S.S.R., "Draft Convention on Principles Governing the Use by States of Artificial Earth Satellites for Direct Television Broadcasting," reprinted in U.N., General Assembly, Report of the Working Group on Direct Broadcast Satellites on the Work of its Fourth Session, U.N. Doc. A/AC.105/117 (1973), Annex III (hereinafter cited as Fourth Working Group Report).

5. U.N. General Assembly, Minister for Foreign Affairs of the U.S.S.R., Request for the Inclusion of a Supplementary Item in the Agenda of the Twenty-Seventh Session, U.N. Doc. A/8771 (1972), at 1-2.

6. Soviet Draft Convention, Fourth Working Group Report, supra note 4, Art. V.

7. Id., Art. III.

8. Id., Art. IX.

9. U.N. General Assembly, Minister for Foreign Affairs of the U.S.S.R., Request for the Inclusion of a Supplementary Item in the Agenda, supra note 5, at 2.

10. K. Queeney, "An Analysis of the Role of the United Nations in the Formulation of Principles Governing Direct Broadcast Satellites," Unpublished Ph.D. dissertation, Ohio University, March 1975, at 195.

11. G.A. Res. 2916, 27 U.N. GAOR Supp. 30, at 14, U.N. Doc. A/8730 (1972).

12. U.S.S.R., "Principles Governing the Use by States of Artificial Earth Satellites for Direct Television Broadcasting," reprinted in U.N. General Assembly, Report of the Working Group on Direct Broadcast Satellites on the Work of its Fifth Session, U.N. Doc. A/AC.105/127 (1974), Annex II.

13. The text of Article VI is reproduced in the text following footnote 46.

14. Soviet Draft Declaration of Principles, supra note 72, Art. VIII(2).

15. Compare Art. V of the Soviet Draft Convention, U.N., supra note 44, Annex III, with Art. V of the Soviet Draft Declaration of Principles, supra note 72, Annex II.

16. See the text accompanying footnotes 8-10.

17. Soviet Draft Declaration, supra note 12, Art. IX(1).

18. Swedish-Canadian "Draft Principles Governing Direct Television Broadcasting by Satellite," in Fourth Working Group Report, supra note 4, Annex IV.

19. Id., Art. V.

20. Id., Art. VIII.

21. Compare Soviet Draft Convention, Fourth Working Group Report, supra note 4, Art. VI, with the Swedish-Canadian Draft Principles, id., Annex IV, Art. VIII.

22. Id., Art. VI.

23. Id., Art. X.

24. The United States of America, "Draft Principles on Direct Broadcast Satellites," U.N. Doc. A/AC.105/WG.3(V)/CRP.2 (March 1974), reprinted in U.N. General Assembly, Report of the Working Group on Direct Broadcast Satellites on the Work of its Fifth Session, supra note 12, Annex IV.

25. Id., Arts. I and II.

26. Id., Arts. III and IV.

27. Id., Art. IV.

28. Id., Art. V.

29. Id., Arts. VI-IX.

30. Id., Art. X.

31. Id., Art. XI.

32. Fifth Working Group Report, supra note 12, at 10.

33. Id.

34. U.N. General Assembly, Report of the Legal Sub-Committee Report on the Work of its Fourteenth Session, U.N. Doc. A/AC.105/147 (1975), Annex II, at 1-2 (hereinafter cited as Fourteenth Legal Sub-Committee Report).

35. U.N. General Assembly, Report of the Legal Sub-Committee on the Work of its Fifteenth Session, U.N. Doc. A/AC.105/171 (1976), Annex II, at 1 (hereinafter cited as Fifteenth Legal Sub-Committee Report).

36. Fourteenth Legal Sub-Committee Report, supra note 34, Annex II, at 2.

37. Id.

38. Id.

39. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, January 27, 1967, [1967] 18 U.S.T. 2410, T.I.A.S. 634, 610 U.N.T.S. 205, entered into force for the United States on October 10, 1967.

40. Fifteenth Legal Sub-Committee Report, supra note 35, Annex II, at 1-2.

41. Id., at 2.

42. Fifth Working Group Report, supra note 12, at 11.

43. Id.

44. Fourteenth Legal Sub-Committee Report, supra note 34, Annex II, at 2.

45. See "Model General Principles for the Use of Artificial Earth Satellites for Radio and Television Broadcasting," U.N. General Assembly, Report of the Working Group on Direct Broadcast Satellites on the Work of its Third Session, U.N. Doc. A/AC.105/83 (1970), Annex IV, at 27. 1972 Soviet Draft Convention, supra note 4, Art. XII: "Principles Governing the Use of States of Artificial Earth Satellites for Direct Television Broadcasting," Fifth Working Group Report, supra note 12, Annex II, Art. VII.

46. Fourteenth Legal Sub-Committee Report, supra note 34, Annex II, at 2.

47. Fifteenth Legal Sub-Committee Report, supra note 35, Annex II, at 2.

48. Fifth Working Group Report, supra note 12, at 11.

49. Fourteenth Legal Sub-Committee Report, supra note 34, Annex II, at 3.

50. Fifteenth Legal Sub-Committee Report, supra note 35, Annex II, at 2.

51. Fifth Working Group Report, supra note 12, at 13. Art. VI of the Outer Space Treaty provides:

> States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the moon and other celestial bodies, shall require authorization and continuing supervision by the State concerned. When activities are carried on in outer space, including the moon and other celestial bodies, by an international organization, responsibility for compliance with this Treaty shall be borne both by the international organization and by the States Parties to the Treaty participating in such organization.

52. Id., at 13. Consensus was also reached on the need to resolve disputes through established international procedures. Id., at 19.

53. Fourteenth Legal Sub-Committee Report, supra note 34, Annex II, at 3.

54. Id.

55. Fifteenth Legal Sub-Committee Report, supra note 35, Annex II, at 2.

56. Fourteenth Legal Sub-Committee Report, supra note 34, Annex II, at 5.

57. Fifteenth Legal Sub-Committee Report, supra note 35, Annex II, at 2.

58. <u>Fifth Working Group Report</u>, <u>supra</u> note 12, at 13-14.

59. <u>Id</u>., at 13. <u>See</u> also the text accompanying notes 41-43.

60. <u>Id</u>., at 14.

61. <u>Id</u>., at 14-15. Article 19 of the Universal Declaration of Human Rights provides:

> Everyone has the right to freedom of opinion and expression; this right includes freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media and regardless of frontiers.

62. <u>Id</u>., at 15.

63. <u>Fourteenth Legal Sub-Committee Report</u>, <u>supra</u> note 34, Annex II, at 3.

64. <u>Fourth Working Group Report</u>, <u>supra</u> note 4, Annex IV, at 1-4.

65. <u>Fourteenth Legal Sub-Committee Report</u>, <u>supra</u> note 34, Annex II, at 3-4.

66. <u>Id</u>., at 4.

67. <u>Id</u>., Annex II, at 3-4; <u>Fifteenth Legal Sub-Committee Report</u>, <u>supra</u> note 35, Annex II, at 3-4.

68. <u>Fifth Working Group Report</u>, <u>supra</u> note 12, at 16.

69. <u>Fourteenth Legal Sub-Committee Report</u>, <u>supra</u> note 34, Annex II, at 4.

70. <u>Id</u>.

71. <u>See</u>, <u>e.g.</u>, <u>Fourteenth Legal Sub-Committee Report</u>, <u>supra</u> note 34, Annex II, at 4.

72. <u>Fifteenth Legal Sub-Committee Report</u>, <u>supra</u> note 35, Annex II, at 3.

73. <u>Fifth Working Group Report</u>, <u>supra</u> note 12, at 17.

74. Compare the listing in ibid., with Arts. IV and VI of the Soviet Draft Convention, U.N. General Assembly, <u>Fourth Working Group Report</u>, <u>supra</u> note 44, Annex III, and with Art. IV of the Soviet Draft Declaration of Principles, U.N. General Assembly, <u>Fifth Working Group Report</u>, <u>supra</u> note 12, Annex II.

75. _Fifth Working Group Report_, _supra_ note 12, at 17.

76. _Id_.

77. _Fourteenth Legal Sub-Committee Report_, _supra_ note 34, Annex II, at 4.

78. _Id_.

79. _Fifth Working Group Report_, _supra_ note 12, at 18.

80. _Id_.

81. _Id_.

82. _Fifteenth Legal Sub-Committee Report_, _supra_ note 35, Annex II, at 4

83. _Compare Fourteenth Legal Sub-Committee Report_, _supra_ note 34, Annex II, at 4-5, with Soviet Draft Principles, _Fifth Working Group Report_, _supra_ note 12, Annex II, at 2, Art. VI.

84. _Fourteenth Legal Sub-Committee Report_, _supra_ note 34, Annex II, at 4-5.

85. Compare _id_., at 5, with Soviet Draft Principles, in _Fifth Working Group Report_, _supra_ note 12, Annex II, Art. IX(1). Article 33 of the United Nations Charter calls upon nations to employ "negotiations, enquiry, mediation, conciliation, arbitration, judicial settlement, resort to regional agencies or arrangements, . . . " before any other.

86. For a discussion of the ATS 1, 3, 5 and 6 experiments, _see_ D. Smith, _Communication Satellite User Experimentation. A Technology in Transition_ Chs. 3-7, 9 (to be published in 1977).

87. For a more complete discussion of the SITE experiments _see_ _id_., Ch. VII.

88. U.N., Committee on the Peaceful Uses of Outer Space, _Report of the United Nations Panel Meeting on Satellite Broadcasting Systems for Education_, U.N. Doc. A/AC.105/128 (1974), Annex I, at 3 (hereinafter cited at _U.N. Panel Report_).

89. _Id_., at 5.

90. _Id_., at 4, and Annex I, at 1.

91. _Id_., Annex I, at 1-2.

92. *Id.*, at 9-10.

93. U.N. General Assembly, *Report of the Working Group on Direct Broadcast Satellites on the Work of its First Session*, U.N. Doc. A/AC.105/51 (1969), para. 9[a] (hereinafter cited as *First Working Group Report*).

94. Ithiel de Sola Pool, "The Satellite Broadcast Controversy," M.I.T.: A Report for the Center for International Studies (1974), at 26.

95. ASIL *Direct Broadcasting from Satellites*, *supra* note 2, at 5.

96. *See* the "Memorandum of Understanding Between the Department of Atomic Energy of the Government of India and the United States National Aeronautics and Space Administration," 18 September 1969, para. 3.2.

97. *U.N. Panel Report*, *supra* note 88, at 19.

98. *Id.*

99. *Id.*, at 20.

100. Comment of Nandasiri Jasentuliyana, in Panel Discussion, "Direct Satellite Broadcasting and the Third World," 13 *Columbia Journal of Transnational Law* 68 (1974).

101. *First Working Group Report*, *supra* note 93, para. 8.

102. The frequencies allocated range from 620 MHz to 86 GHz, and standard UHF television transmissions occur in the 450 MHz to 900 MHz range. *See* "The World Administrative Radio Conference for Space Telecommunications," 38 *Telecommunications Journal*, 678-79 (1971); *see* also A. Chayes, and L. Chazen, "Policy Problems in Direct Broadcasting from Satellites," 5 *Stanford Journal of International Studies* 10 (1970).

103. *See* D. Smith, *Communications Via Satellite: A Vision in Retrospect* 195-96 (1976).

104. *See* Section II.B. in Part III.

105. *See*, for example, the Soviet Draft Declaration, Art. V, in *Fifth Working Group Report*, *supra* note 12, Annex II, the Soviet Draft Convention, *Fourth Working Group Report*, *supra* note 4, Art. V and the Swedish-Canadian Draft Principles, *supra* note 18, Art. V.

106. _See_, _e.g._, Ruddy, "Broadcasting Satellites: An American Perspective," 3 _Lawyer of the Americas_ 499, 503 (1971). Among the relevant instruments are the First Amendment to the Constitution of the United States; the Universal Declaration of Human Rights, G.A. Resol. 217A (III), 10 December 1948; The International Convention on the Elimination of All Forms of Racial Discrimination (articles 4 and 5) adopted by U.N. General Assembly Res. 2106A (XX) of 21 December 1965, and entering into force on 9 January 1969; The International Covenant of Civil and Political Rights (Article 19), adopted by U.N. General Assembly Res. 2200 (XXI), 16 December 1966; The European Convention of Human Rights (Article 10), signed at Rome, 9 November 1950, entered into force 3 September 1953; The American Declaration of the Rights and Duties of Man (Article IV), Res. XXX adopted at the Ninth International Conference of American States, Bogota, Colombia, 30 March to 2 May 1948; and The American Convention on Human Rights (Article 13), signed on 22 November 1969, at the Inter-American Specialized Conference on Human Rights, San Jose, Costa Rica.

107. U.N. General Assembly, _The International Covenant of Civil and Political Rights_, _supra_ note 106, Art. 20. For similar limitations on the principle of free flow in other international instruments, see T. Buergenthal, "The Right to Receive Information Across National Boundaries," in Aspen Institute Program on Communication and Society, _Control of the Direct Broadcast Satellite: Values in Conflict_ 76-68 (1974).

108. Laskin, "Legal Strategies for Advancing Information Flow," Aspen Institute, _Control of the Direct Broadcast Satellite_, _supra_ note 107, at 62.

109. L. Marks, "International Conflict and the Free Flow of Information," in Aspen Institute, _Control of the Direct Broadcast Satellite_, _supra_ note 107, at 69.

110. Ruddy, _supra_ note 106, at 503-504.

111. _Accord_, Laskin, "Legal Strategies," _supra_ note 108, at 61.

112. _Id._

113. _Id._

114. _See_, _e.g._, the Soviet Draft Declaration, Arts. IV and V, in _Fifth Working Group Report_, _supra_ note 12; Soviet Draft Convention, Arts. IV, V and VI, _supra_ note 4.

115. Swedish-Canadian Draft Principles, _supra_ note 18, Art. V.

75

116. ASIL Panel, Direct Broadcasting from Satellites, supra note 2, at 30.

117. Id.

118. Proposals for the exclusion of spillover from the prior consent regime are discussed below in the text accompanying notes 127-133.

119. UNESCO Declaration of Guiding Principles in the Use of Satellite Broadcasting for the Free Flow of Information, the Spread of Education and Greater Cultural Exchange, U.N. Doc. A/AC.105/109 (1972), Art. V(1). For further information see D. Smith, Communications Via Satellite: A Vision in Retrospect 199-200 (1976).

120. UNESCO, Declaration of Guiding Principles, supra note 167, Art. V(2).

121. Id., Art. VI(2).

122. Id., Art. VII(2).

123. On the doctrine of "harmful effects," see D. Smith, International Telecommunication Control 185-205 (1969).

124. UNESCO, Declaration of Guiding Principles, supra note 167, Art. IX(2).

125. Laskin and Chayes, "A Report of the Panel on International Telecommunications Policy," in ASIL Panel, Direct Broadcasting from Satellites, supra note 2, at 9.

126. See also Laskin, "Legal Strategies," in the Aspen Institute, Control of Direct Broadcasting Satellites, supra note 108, at 62.

127. Chayes and Chazen, "Policy Problems," supra note 102, at 15.

128. Comment of Abram Chayes in Panel Discussion, "Direct Satellite Broadcasting," supra note 100, at 78.

129. Note, "Approaches to Controlling Propaganda and Spillover from Direct Broadcast Satellites," 5 Stanford Journal of International Studies 175 (1970).

130. Id.

131. The text of § 428A is reprinted in the text accompanying note 41.

132. Fourth Working Group Report, supra note 4, Annex IV, Art. VI; Fifth Working Group Report, supra note 12, Annex III, Art. VI.

133. Id., Art. VIII.

134. U.N., UNESCO, Declaration of Guiding Principles, supra note 119, Art. VI(2).

135. Fifth Working Group Report, supra note 12, Annex III, Art. V.

136. Dalfen, "Direct Satellite Broadcasting," 20 University of Toronto Law Journal 366, 373 (1970).

137. U.N., UNESCO, Declaration of Guiding Principles, supra note 119, Art. VI(2).

138. Swedish-Canadian Draft Principles, Fifth Working Group Report, supra note 12, Annex III, Art. V.

139. See, for example, Dalfen, "Direct Broadcasting," supra note 136, at 373; E. McAnany, "Reflections on the International Flow of Information," in The Aspen Institute, Control of the Direct Broadcast Satellite: Values in Conflict 16 (1974).

140. See Ruddy, "Broadcasting Satellites," supra note 106, at 503.

141. Comment, "Direct Broadcast Satellites: Implications for Less Developed Countries," 12 Virginia Journal of International Law 84 (1971).

142. United States Draft Principles, Fifth Working Group Report, supra note 12, Annex IV, Art. V.

143. See also Marks, supra note 109, at 66.

II. IMPLICATIONS OF THE CPUOS DEBATES ON EARTH RESOURCES SATELLITES FOR SPACE INDUSTRIALIZATION

1. See, e.g., Report of the Working Group on Remote Sensing of the Earth by Satellites on the Work of its Third Session, U.N. Doc. A/AC.105/125 (1973).

2. Report of the Legal Sub-Committee on the Work of its Twelfth Session, U.N. Doc. A/AC.105/115 (1973), at 14 [hereinafter cited as Twelfth Legal Sub-Committee Report].

3. U.N. Doc. A/C.1/1047, October 15, 1974 [hereinafter cited as Argentina-Brazil Draft Treaty]. The joint proposal superceded both Argentina's Draft International Agreement on Activities Carried Out Through Remote Sensing Satellites Surveys of Earth Resources, U.N. Doc. A/AC.105/C.2/L.73 and Brazil's Draft Treaty on Remote Sensing of Natural Resources by Satellite, U.N. Doc. A/AC.105/122. Both individual proposals are reprinted in the Report of the Legal Sub-Committee on the Work of its Thirteenth Session, U.N. Doc. A/AC.105/133 (1974), Annex IV, at 1-3 and 3-5, respectively [hereinafter cited as Thirteenth Legal Sub-Committee Report].

4. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 610 U.N.T.S. 205, 18 U.S.T. 2410, T.I.A.S. No. 6347, *entered into force* October 10, 1967.

5. U.N. Doc. A/AC.105/C.2/L.99, May 27, 1974 [hereinafter cited as Soviet-French Draft Principles]. The joint document superceded both the Draft Principles Governing Remote Sensing of Earth Resources from Outer Space submitted by France, U.N. Doc. A/AC.105/L.69, and the Model Draft Principles Governing the Use of Space Technology by States for the Study of Earth Resources, submitted by the Soviet Union, U.N. Doc. A/AC.105/C.2/L.88. All three are reprinted in Thirteenth Legal Sub-Committee Report supra note 3, at Annex IV, at 9-10, 5-8, and 9, respectively.

6. Id., Article 2.

7. Id., Article 5(b).

8. Id., Article 5(c).

/

9. *Id.*, Article 5(a).

10. *Id.*, Article 6.

11. U.N. Doc. A/AC.105/C.2/L.103 (19 February 1975) preambular paragraphs 3 and 4.

12. *See* Report of the Legal Sub-Committee on the Work of its Fourteenth Session, U.N. Doc. A/AC.105/197 (1975), Annex III, at 2 [hereinafter cited as *Fourteenth Legal Sub-Committee Report*].

13. Report of the Legal Sub-Committee on the Work of its Fifteenth Session, U.N. Doc. A/AC.105/171, Annex III, at 2 - 3 [hereinafter cited as *Fifteenth Legal Sub-Committee Report*].

14. *See* the analysis of Article I in Section I.A. of Part II above.

15. *See*, *e.g.*, the working paper on remote sensing submitted to CPUOS by the United States delegation entitled "Remote sensing of the *natural environment* of the earth from outer space," U.N. Doc. A/AC.105/L.103, 19 February 1975 (emphasis added).

16. *See*, *e.g.*, Declarations of Principles Governing the Sea-Bed and the Ocean Floor, and the Subsoil Thereof, beyond the Limits of National Jurisdiction, G.A. Res. 2749, 25 U.N. GAOR Supp. 28, at 24, U.N. Doc. A/8028 (1970).

17. *See* Fifteenth Legal Sub-Committee Report, *supra* note 13, Annex I, at 2 - 3. For a discussion of the moon treaty, *see* Section III below.

18. For a more extensive discussion of the common heritage principle, *see* Section IV of Part III, below.

19. *Fourteenth Legal Sub-Committee Report*, *supra* note 12, Annex III, at 2.

20. *See*, *e.g.*, G.A. Res. 2151 (XXV) (1970).

35. _See_ Section I.A.1. in Part II above.

36. A similar provision is continued in Article XIII of the Argentine-Brazilian Draft Treaty, U.N. Doc. A/C.1/1047 (1974), reprinted in _Thirteenth Legal Sub-Committee Report_, _supra_ note 32, Annex IV.

37. _See_ S. 657, 95th Cong., 1st Sess. (1977).

38. _See_ Hearings on S. 3374 Before the Senate Committee on Aeronautical and Space Sciences, 91st Cong., 2d sess. (1970), part III, at 1063-64.

39. Report of the Working Group on Remote Sensing of the Earth by Satellites in the Work of its Third Session, U.N. Doc. A/AC.105/125, March 13, 1974, at 12.

III. IMPLICATIONS FOR SPACE INDUSTRIALIZATION OF THE CPUOS DEBATES ON THE DRAFT MOON TREATY

1. Argentina, Draft Agreement on Principles Governing Activities in the Use of the Natural Resources on the Moon and Other Celestial Bodies, U.N. Doc. A/AC.105/C.2/C.71 (1970).

2. U.S.S.R., Draft International Treaty Concerning the Moon, A/8391 (1971).

3. G.A. Res. 2779 (XXVI) (1971).

4. *See* Report of the Legal Sub-Committee on the Work of its Eleventh Session, U.N. Doc. A/AC.105/101 (1972).

5. Report of the Chairman of Working Group I (Moon Treaty), in *Report of the Legal Sub-Committee on the Work of Its Fourteenth Session*, A/AC.105/147 (11 March 1975), Annex I, at 1 (hereinafter cited as *Fourteenth Legal Sub-Committee Report*).

6. Stephen Gorove, Property Right in Outer Space: Focus on the Proposed Moon Treaty; 2 *Journal of Space Law* 27, 30 (1974); L.F.E. Goldie, "Is There A General International Law of Original Ownership? The Possible Relevance of General Doctrines Governing the Possession of Deep Ocean-Bed Resources, in Proceedings of the *Nineteenth Colloquium on the Law of Outer Space* 288-289 (1977).

7. Goldie, supra note 6, at 288-289.

8. *Id.*

9. *See, e.g.*, E. Vassilevskaya, Legal Regulation of Activitie on the Moon for the Cause of Peace and Progress, *Proceedings of the Fifteenth Colloquium on the Law of Outer Space* 180 (1973).

10. Gorove, *supra* note 6, at 30.

11. Gorove, Legal Status of the Natural Resources of the Moon and Other Celestial Bodies, *Proceedings of the Sixteenth Colloquium on the Law of Outer Space* 179 (1974).

12. *See* Argentina, "Draft Treaty Relating to the Moon - Question of the 'Common Heritage of All Mankind'," U.N. Doc. A/AC.105/115 (1973) Annex I, at 29, *see also* A. Cocca, The Principle of the "Common Heritage of All Mankind" As Applied to Natural Resources from Outer Space and Celestial Bodies, in *Proceedings of the Sixteenth Colloquium on the Law of Outer Space* 173 (1974).

13. Argentine Draft Treaty, supra note 12, at 30; Cocca, supra note 30, at 175.

14. Cocca, supra note 30, at 175.

15. Union of Soviet Socialist Republics: working paper "Draft Treaty Relating to the Moon -- Question of the "Common Heritage of All Mankind" U.N. Doc. A/AC.105/115 (1973), Annex I, at 24-25.

16. E. Vassilevskaya, "Drawing Up a Draft Treaty on The Moon -- a Further Contribution to the Progressive Development of International Space Law," in Proceedings of the Nineteenth Colloquium on the Law of Outer Space 101 (1977).

17. See, e.g., Gorove, supra note 11, at 179.

18. Id, at 177-78.

19. Stephen Gorove, The Draft Treaty Relating to the Moon: An Overview and Evaluation," in Proceedings of the Nineteenth Colloquium on the Law of Outer Space 44 (1977).

20. See, e.g., Dr. Laszlo Szaloky, The Way of the Further Perfection of the Legal Regulation Concerning the Moon and Other Celestial Bodies, Especially Regarding the Exploration of Natural Resources of the Moon and Other Celestial Bodies, in Proceedings of the Sixteenth Colloquium on the Law of Outer Space 198 (1974), and Vladimir Kopal, The Development of Legal Arrangements for the Peaceful Uses of the Moon, in Proceedings of the Fifthteenth Colloquium on the Law of Outer Space 163 (1973).

21. See, e.g., Cocca, supra note 12, at 172-76, R. V. Dekanozov, "Relationship Between the Status of Outer Space and the Statuses of Areas Withdrawn from State Sovereignty", E.G. Vassilevskaya, "Introductory Report to Part IV", and Vladimir Kipal, "Legal Questions Relating to the Draft Treaty Concerning the Moon", Proceedings of the Sixteenth Colloquium on the Law of Outer Space (1973), at 10, 170 and 183-4, respectively.

22. Vassilevskaya, supra note 16 at 100-101; Proceedings of the United Nations Committee on the Peaceful Uses of Outer Apace, 19th Session, U.N. Doc. A/AC.105/PV 164 (1976), Statement by Delegate Cocca from Argentina and Proceedings of the United Nations Committee on the Peaceful Uses of Outer Space, 18th Session, U.N. Document A/AC.105/PV 146 at 58-60, Statement by Ambassador Bennett of the United States.

23. Proceedings of the United Nations Committee on the Peaceful Uses of Outer Space, 19th Session, U.N. Doc. A/AC.105/PV 164, Statement by delegate Macaulay from Nigeria.

24. Proceedings of the United Nations Committee on the Peaceful Uses of Outer Space, 18th Session, U.N. Doc. A/AC.105/PV 147 (1975), at 72-73, statement by delegate Bassols from Mexico; and Proceedings of the United Nations Committee on the Peaceful Uses of Outer Space, 19th Session, U.N. Doc. A/AC.105/PV160 (1976), statement by delegate Salatun from Indonesia.

25. Proceedings of the United Nations Committee on the Peaceful Uses of Outer Space, 18th Session, U.N. Doc. A/AC.105/PV 149 (1976), at 59-60, statement by delegate de Lims from Brazil.

26. Edward R. Finch, and Amanda Lee Moore, Outer Space Law and the Global Community, 8 The International Lawyers, October 760-761 (1974).

27. Gorove, supra note 19, at 43.

28. Vladimir Kopal, Legal Questions Relating to the Draft Treaty Concerning the Moon; in Proceedings of the Sixthteenth Colloquium of the Law of Outer Space 181 (1974); E. Vassilevskaya, Legal Problems of the Exploration of the Moon and Other Planets, in Proceedings of the Sixteenth Colloquium on the Law of Outer Space 168-169 (1974); G.C.M. Reijonen, The History of the Draft Treaty on the Moon, in Proceedings of the Nineteenth Colloquium on the Law of Outer Space 361 (1977).

29. Vassilevskaya, supra note 28, at 169-70.

30. India: working paper, Draft Treaty Relating to the Moon, U.N. Doc. A/AC.105/115 (1973), Annex I, at 22.

31. Bulgaria: working paper, Draft Treaty Relating to the Moon, U.N. Doc. A/AC.105/133 (1974), Annex I, at 6.

☆ U S GOVERNMENT PRINTING OFFICE 1978—740-193/405 REGION NO 4